New Scientist

**WEEKLY** 9 October 2021

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How the skin triggers sexual desire

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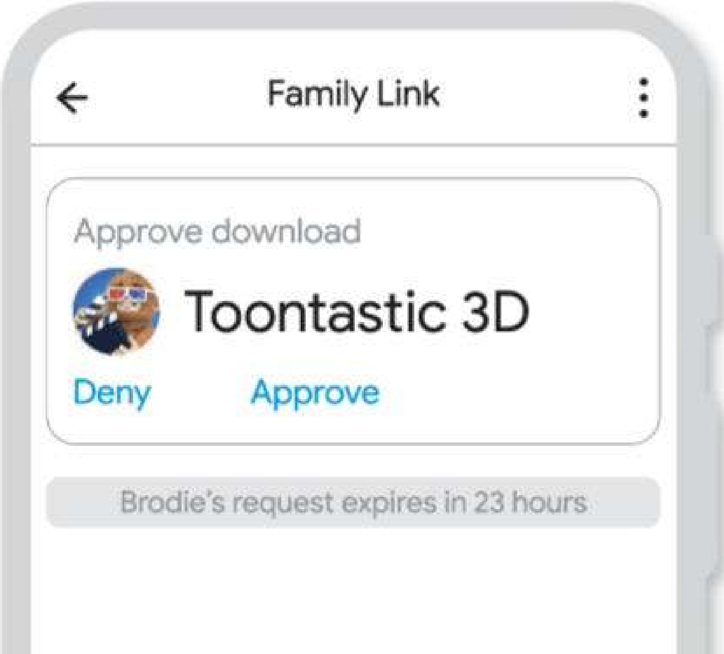

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Is human-like machine intelligence simply a matter of scale?

New Scientist
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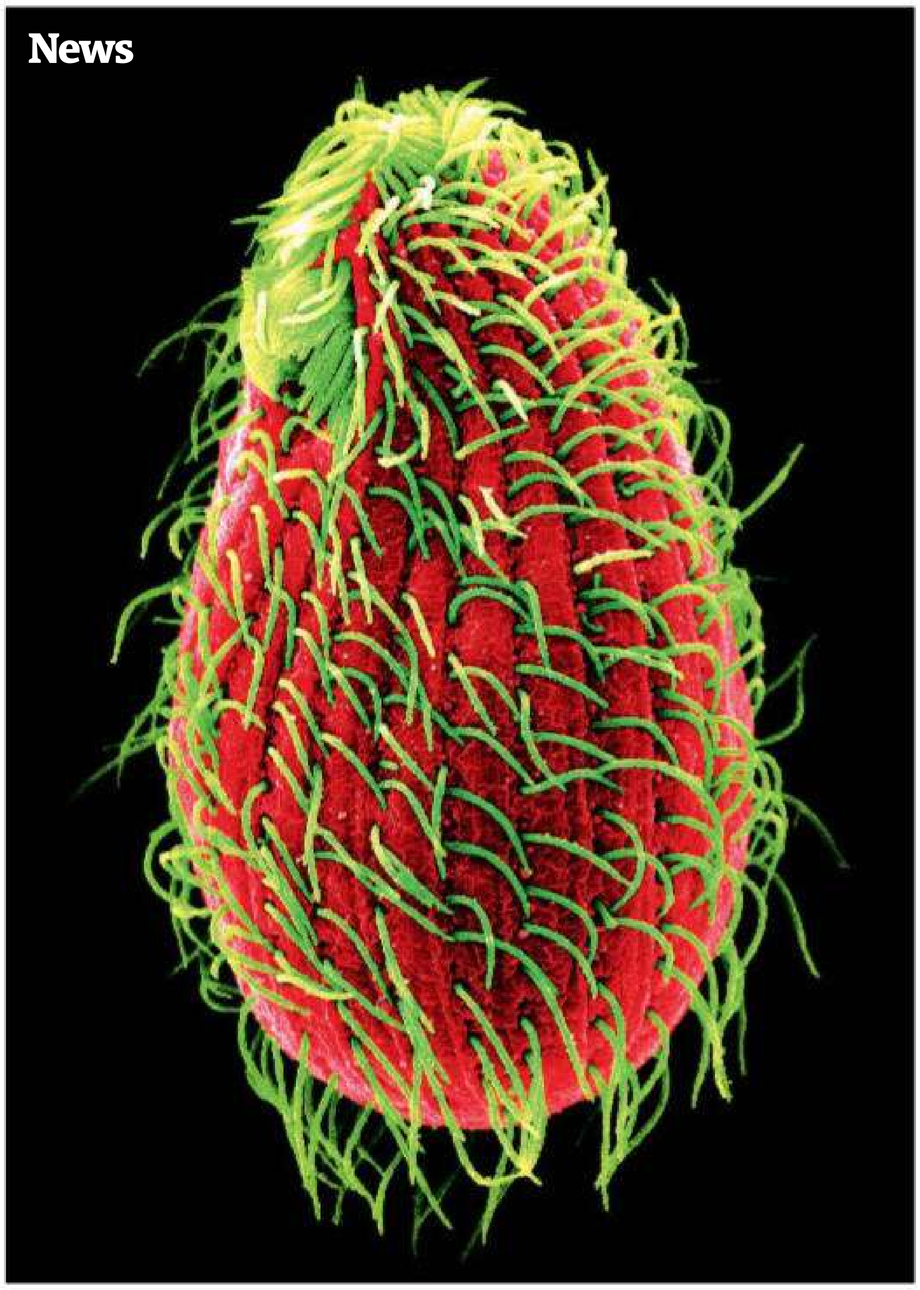

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### Sleep engineering

Neuroscientist Penelope Lewis introduces the new science of sleep engineering. She believes it can be used to slow cognitive ageing, as well as enhance memory and emotional processing and will give some tips on how to apply the ideas yourself. Join us on 28 October at 6pm BST (1pm EDT).

**newscientist.com/ns-events**

## Digital

### Covid-19 daily update

Stay on top of all the latest and most crucial developments in the pandemic with our daily briefing, updated at 12pm BST every weekday. We round up the day's most crucial coronavirus news, plus give links to exclusive news, features and interviews.

**newscientist.com/coronavirus-latest**

## Podcast

### Weekly

CRISPR gene-edited food has gone on sale commercially for the first time. The team finds out about the "super tomato" created by a start-up in Japan. Ever wondered why leaves change colour in autumn? The team discusses an evolutionary explanation suggesting that leaf colour is a signal. Plus: why Germany's recent election could be positive for climate action; and how miniature black holes may have created some of the moon's craters.

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**British sea power** How easy is it to expand offshore wind farms?

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**Super tomato** The first ever gene-edited food goes on sale in Japan

## Video

### Butterfly vision

The ability to see in ultraviolet light is common in animals. But the ability to distinguish two "colours" of UV is rare. Watch the experiments that showed female red postman butterflies can do this, even though the males can't. Don't forget to subscribe to our channel for more amazing explainers and on-camera experiments.

**youtube.com/newscientist**

## Newsletter

### Fix the planet

Chief reporter Adam Vaughan's weekly newsletter on all things climate – sign up to get it free to your inbox. In the latest instalment, Adam takes a boat to Rampion wind farm off the UK's south coast to find out how easy it is to extend existing wind power sites.

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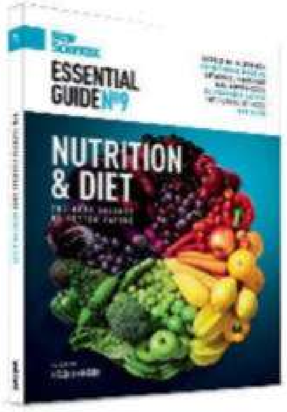
Newsletter

> **"At the foot of the turbines and their hulking substations, they look enormous"**



## Essential guide

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# The great reboot

Advances in AI and quantum computing are coming thick and fast

THERE are two grand ambitions now for computer science: truly intelligent machines and useful quantum computers. Recent developments suggest not only that these goals should be achievable, but that they could be closer than we think.

Take the quest to develop artificial general intelligence (AGI) – AIs that go well beyond being good at one specific task, but can instead do anything a human can. Some people still think this is impossible. And yet analysis of AIs designed to master human language has prompted other experts to suggest that AGI might only be a matter of scaling up current technology. Build gigantic AIs and true, human-level intelligence will come, they say.

This "scaling hypothesis" has come to the fore largely thanks to GPT-3, an AI released by San Francisco-based OpenAI last year that generates remarkably fluent streams of human language on command. GPT-3 is just a scaled-up version of GPT-2, a similar predecessor. This new neural network boasts an order of magnitude more parameters, equivalent to the number of synapses linking neurons in real brains, than its forerunner.

> "Truly intelligent machines and useful quantum computers might be closer than we think"

Researchers who evaluate such language AIs have been surprised by just how much more advanced GPT-3 is than GPT-2. It can do things it wasn't trained to do, for example, and there are hints that it might be capable of human-like reasoning (see page 36).

Time will tell if the scaling hypothesis is right. In the meantime, it will be interesting to see if the AI players with the deepest pockets, such as DeepMind, follow OpenAI's focus on scaling.

However, when it comes to genuinely useful quantum computers, there is no doubt that scaling is key – we are going to need machines with thousands of qubits, the quantum version of a classical bit. This is why the news that researchers have demonstrated a viable way to make sure those qubits don't constantly fall prey to errors is a big deal (see page 9). We might finally have a way to scale up the number of operational qubits to what we need.

There are still no guarantees. Even so, it seems that computer science is striding into the 2020s in rude health. ▮

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FIONA GOODALL/GETTY IMAGES

**A vaccination centre in Auckland, New Zealand**

**Coronavirus**

# Delta in New Zealand

The highly contagious delta variant has pushed New Zealand to think beyond its zero-covid strategy, reports **Alice Klein**

RESTRICTIONS are being rolled back in Auckland, New Zealand, where a coronavirus outbreak has continued to grow despite a strict seven-week lockdown. Some experts fear the move will lead to a spike in cases that will overwhelm the health system, since only just over 50 per cent of people in Auckland are fully vaccinated, but the government has come under public pressure to ease the gruelling strictures.

Early in the pandemic, New Zealand opted for a covid-19 elimination strategy, which meant banning international visitors and rapidly locking down whenever cases were detected. This approach paid off – in early August 2021, the country celebrated five months without any locally acquired cases.

Then, on 17 August, a man in Auckland – New Zealand's most populous city – tested positive for the delta variant. The city immediately locked down, meaning residents could only leave their homes for essential reasons, and schools and non-essential businesses were shut.

Despite this, the number of people infected has since grown to more than 1350. This is partly because the virus has taken hold in marginalised communities that find it harder to comply with the lockdown rules, says Michael Baker at the University of Otago in New Zealand. "Many have drug and alcohol dependencies, mental health issues and precarious living situations," he says.

Auckland's situation reflects that of Sydney and Melbourne in Australia, which also quickly went from having no covid-19 to large outbreaks due to the delta variant.

On 4 October, New Zealand prime minister Jacinda Ardern conceded in a press conference that "a long period of heavy restrictions has not got us to zero cases" and said that the delta variant had felt like "a tentacle that has been incredibly hard to shake".

Although Ardern didn't explicitly declare the end of the elimination strategy, she outlined a three-stage plan to transition Auckland out of lockdown, even though the virus is still circulating.

The first stage, due to come into effect on 6 October soon after *New Scientist* went to press, allows 10 people from two households to meet outdoors. Nurseries for children can reopen and outdoor recreation is permitted.

The government will monitor the situation before triggering the second stage, which will allow 25 people to meet outdoors and shops and some public facilities to reopen. The third stage will allow social gatherings of up to 50 people and hospitality venues and schools to reopen.

"I think people were getting exasperated with the lockdown, so the government felt like they needed to act and do something different," says Baker. "But the worry now is that we will start to see cases rise rapidly and the health system won't cope, especially as we have quite a low number of ICU beds."

Siouxsie Wiles at the University of Auckland agrees. "I think the government felt they had to do this to keep people onside, but I wish we could have kept the elimination strategy going until we had more people vaccinated and the vaccine was available to under 12s," she says.

New Zealand's vaccination roll-out had a slow start due to difficulties securing vaccines, but it has rapidly accelerated in recent weeks. About 79 per cent of people over the age of 12 have now had their first dose.

The nation's elimination strategy should still be considered a success considering that only 27 people in New Zealand have died of covid-19 to date, says Wiles. "We've had an amazing pandemic compared to other countries, but now we're moving into a different phase and we have to get mentally and physically prepared for it." ▮

Medicines

# Ivermectin buyers clubs

People in the UK are trying to source a parasite drug to use as an unproven treatment for covid-19, reveals **Chris Stokel-Walker**

DIMAS ARDIAN/BLOOMBERG VIA GETTY IMAGES

**Self-medicating with ivermectin for covid-19 could be dangerous**

MULTIPLE "buyers clubs" are trying to import the drug ivermectin to the UK to prevent and treat covid-19, even though there is no evidence supporting use of the drug in this way, and it could even be dangerous.

The UK Medicines and Health products Regulatory Authority (MHRA) has cautioned people not to try to buy ivermectin through third parties to treat covid-19. The drug is used to treat parasite infections in humans and some other animals, but has gained a lot of attention as an unproven drug for preventing or treating covid-19.

"Ivermectin is not a licensed medicine for covid-19. It can only be taken by those participating in closely supervised and highly regulated clinical trials," an MHRA spokesperson told *New Scientist*. "Never self-prescribe or try to obtain medicines from an unregulated source – only take medicines prescribed by your doctor and obtained via a registered pharmacy or reputable outlet."

## Highly concentrated

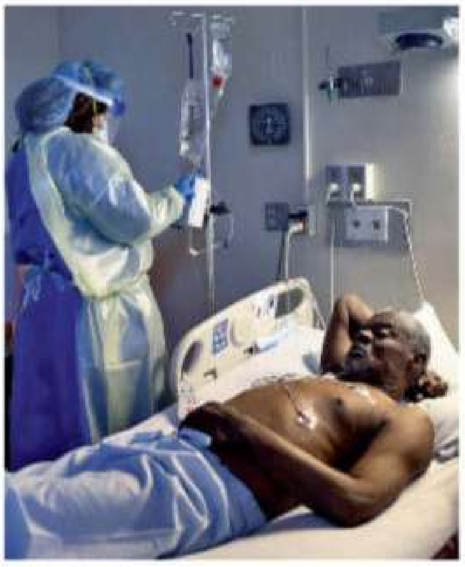
In the US, supplies of the human and livestock forms of ivermectin have run short after some people opposed to covid-19 vaccines sought to use it to treat or prevent infection. But according to the US Food and Drug Administration (FDA), current evidence doesn't show that ivermectin is effective against covid-19 – although clinical trials are ongoing.

"Taking large doses of ivermectin is dangerous," the FDA says on its website. The FDA also warns that formulations of ivermectin for animals are often highly concentrated and may contain inactive ingredients that haven't been evaluated for use in people. Poison control centres in the US are struggling with a surge of ivermectin-related cases, and health officials in New Mexico recently reported that two people died from ivermectin toxicity after taking the drug.

Throughout the pandemic, a number of drugs have attracted attention as possible preventatives of or treatments for covid-19. Like the anti-malarial drug hydroxychloroquine before it, ivermectin is being used by some people with covid-19 to try to halt the onset of symptoms, and by some people who are against vaccines as a preventative measure. Trials of hydroxychloroquine haven't found evidence of any benefits of using it for covid-19.

The desire of some to source ivermectin for covid-19 isn't limited to the US. A crowd-funded campaign in the UK called the Ivermectin Approval Club has raised more than £40,000 in a bid to gain MHRA approval for the use of ivermectin to treat covid-19.

**A man with covid-19 receives remdesivir in Chicago, Illinois**



SCOTT OLSON/GETTY IMAGES

If approved, the group says it would then plan to source ivermectin formulated for human use from a Bulgarian company and distribute it among members.

"We've hired regulatory consultants to submit the application for us," says Tess Lawrie of the Ivermectin Approval Club, run by UK non-profit organisation EbMCsquared. "It's a very slow process."

Lawrie believes ivermectin is a safe and effective treatment for covid-19 that can reduce the risk of people dying from the disease, and wants people to have the chance to use it – perhaps as a prophylactic for those at high risk.

But others are trying to source ivermectin without seeking regulatory approval. *New Scientist* has seen messages shared in a group on the encrypted chat app Telegram that calls itself the Ivermectin Buyers Club. The chat group isn't connected to the group seeking MHRA approval. It has around 1300 members, and the group's administrator has offered to supply ivermectin to buyers around the world for £3 a tablet.

"Ivermectin is not a licensed medicine for covid-19. It can only be taken by those in closely supervised trials"

The seller, who goes by the pseudonym Ron Woodroof – a reference to the creator of the Dallas Buyers Club, which purchased AIDS treatments in the 1980s – offered to send the tablets to me when I posed as someone interested in purchasing ivermectin.

In both a private chat and in the public group, Woodroof claimed to source the drug from a pharmacist in India and import it to the UK. Prospective clients seeking a supply of ivermectin in the Telegram group purport to come from all over the world. Woodroof has shared evidence in the group of multiple deliveries to customers.

Woodroof told me he was selling "high grade human ivermectin" that is shipped from the UK. The seller reassured me that "more [ivermectin is] coming at all times so I wouldn't stress".

## Payments in bitcoin

An MHRA spokesperson told *New Scientist* that importing ivermectin into the UK for anything other than personal use is illegal and would constitute a criminal offence. "Anyone in the UK who imports a medicine for personal use, must not sell on, or supply imported medicines to others," said the spokesperson.

In recent weeks, Woodroof has moved to accepting payment for the pills only through the encrypted and difficult-to-track cryptocurrency bitcoin. However, all transactions associated with a given bitcoin wallet are stored permanently on the blockchain, an unalterable ledger. The wallet that Woodroof asked me to send money to has received US$3863 (or 0.09 bitcoin) since the start of September. In all, 42 transactions have been associated with the wallet.

Woodroof stopped responding to me when I identified myself as a reporter. Before that, he deleted the messages we exchanged.

While unproven drugs aren't a credible alternative to vaccines, there have been some legitimate successes in repurposing existing drugs for treating covid-19. The antiviral drug remdesivir has been approved for this purpose by the FDA, as has baricitinib, a rheumatoid arthritis drug, for people on ventilators.

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**Computing**

# Quantum computers can now fix their own mistakes

**Matthew Sparkes**

**QUANTUM computers aren't yet reliable enough for mainstream use, in part because the error rates of their calculations are too high. That could soon change, because for the first time, a quantum computer has demonstrated an error-correction strategy that fixes more errors than it creates. This may provide a practical way to scale up to a machine capable of carrying out genuinely useful computations.**

Ordinary computers store data as either a 0 or 1, but errors can cause the bit to "flip" to the wrong value, which is why error-correction is a standard feature of modern processors. In quantum computing, the problem is more complex because each quantum bit, or qubit, exists in a mixed state of 0 and 1, and any attempt to measure them directly destroys the data.

Several research teams are working on the problem of quantum error correction but there is a long way still to go. Google announced in July that its Sycamore processor was able to detect and fix computational errors, but the additional hardware needed to do that introduced more errors than it was able to fix.

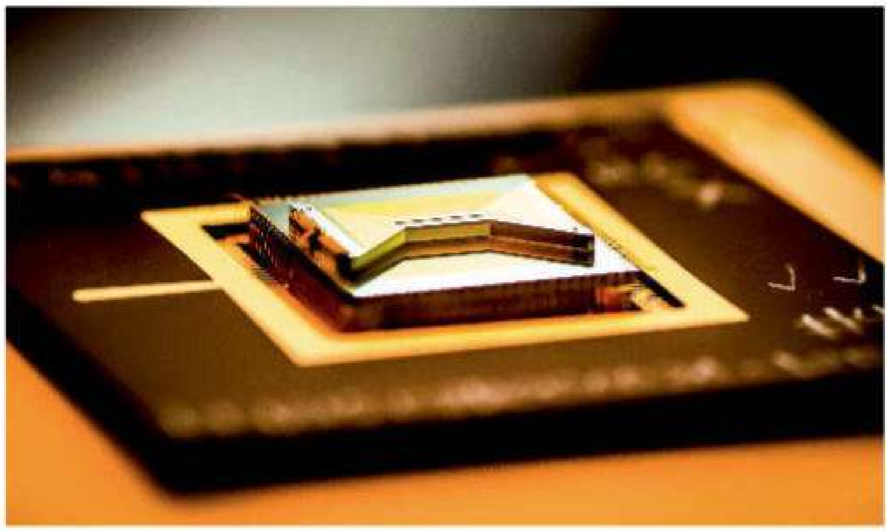
Christopher Monroe at the Joint Quantum Institute (JQI) in Maryland and his colleagues have now passed this crucial threshold. The team was able to set the state of a logical qubit – a group of 13 qubits clustered together to more reliably hold a single piece of data – and then measure it again 99.4 per cent of the time, despite relying on six individual operations that have only 98.9 per cent reliability.

Without error correction, the reliability would be expected to slip down to 93.6 per cent after all six operations (*Nature*, doi.org/gzcn).

Unlike the groups at Google and the University of Science and Technology of China (USTC), which have made big strides in recent months with superconducting qubits, the JQI group uses trapped-ion qubits. The machine uses up to 32 individual charged atoms that are manipulated with lasers.

The inherently higher stability of trapped ions allowed the team to use an error-correction strategy called a Bacon-Shor code, which superconducting qubits aren't currently high enough quality to use.

The ion-trap quantum processor used in the experiment



HUDEK/JQI

Monroe, who is also founder of quantum computing firm IonQ, which floated on the New York Stock Exchange last week, says that error correction is the key to creating practical computers, not simply making more and more qubits. Anyone creating dozens of qubits while having a high error rate is "spinning their wheels", he says, claiming that trapped-ion technology is on a steep upwards slope with only engineering hurdles ahead of it, while superconducting qubits are on a flat trajectory with large scientific breakthroughs needed to progress.

**99.4%**

The reliability of an error-corrected logical qubit

Despite this, the only claims of quantum supremacy so far have both included superconducting qubits, and the number of qubits used in them has been rising steadily over the past year.

Monroe concedes, however, that his team was only able to demonstrate error-correction on a single logical qubit, and that the next challenge is to scale up to two or more. "We need to think higher now," he says.

Peter Knight at Imperial College London agrees that the trapped-ion approach does have some advantages over the superconducting plan being followed by Google and USTC. Ions in a trapped-ion computer are physically identical, whereas superconducting qubits can vary, he says. "With superconducting qubits there's a lot of surface noise. With each qubit you have to do a lot of tuning to make it as identical as you can to another, whereas nature gives you identical trapped ions."

Neuroscience

# Brain implant treats depression

A technique that uses wires inside the brain to respond to patterns of neural activity has helped treat a woman's depression, reports **Clare Wilson**

A WOMAN who had severe depression has successfully been using a radical new treatment, which involves putting electrodes deep into the brain, for one year. "Everything has gotten easier and easier," says Sarah, who is the first to trial the new technique and asked for her full name not be used.

For now, the treatment is likely to be used only in people with the most severe depression, as it involves two brain surgeries along with days of recording the brain's electrical signals to work out a pattern of activity, or "neural biomarker", for each individual's symptoms.

"These results provide hope that a much-needed personalised, biomarker-based treatment for psychiatric disorders is possible," says Katherine Scangos at the University of California, San Francisco.

Crucially, the implant fires only when needed, a few hundred times a day, whenever a specific pattern of brain activity is detected. A simpler form of brain stimulation, in which the device is always on, is already used in the movement disorder Parkinson's disease, where the brain areas involved are relatively well understood.

Such continuous brain stimulation has been tried before in depression, but the results from trials have been mixed, perhaps because the brain circuitry responsible is unclear and may vary from person to person.

When trying to help Sarah, Scangos's team started by recording the electrical activity from 10 different parts of her brain while she reported on her mood, over 10 days.

Sarah had experienced depression since childhood that couldn't be helped by many different drug treatments or by electroconvulsive therapy. Before the surgery, she was experiencing suicidal thoughts several times an hour.

JOHN LOK PHOTOGRAPHY

**Sarah has received a new brain stimulation treatment for depression**

The investigation found that when Sarah's symptoms were at their worst, there was a characteristic pattern of activity, known as gamma brainwaves, in her amygdalae, two small structures deep in the brain that have previously been linked with emotions.

Both the gamma brainwaves and the depression symptoms were alleviated when the implant was switched on in a different part of her brain known as the right ventral capsule/ventral striatum (VC/VS).

"When I first received the stimulation, I felt the most intensely joyous sensation and my depression was a distant nightmare for a moment," says Sarah.

The VC/VS was also already thought to be involved in depression. It has been targeted in some of the past trials of continuous brain stimulation, and a few people with very severe depression have the region removed through brain surgery. "In the context of what's gone on before, it makes a lot of sense," says Ludvic Zrinzo at University College London Hospitals, who carries out such operations.

High-frequency stimulation, the sort done in the new study, is thought to reduce brain activity by preventing the nearby brain cells from firing as normal, temporarily mimicking the effects of surgery. It seems that in Sarah's case, the stimulation turns down the right VC/VS, which dampens gamma brainwaves in the right amygdala – scans showed that these two structures are highly connected in her brain (*Nature Medicine*, doi.org/gzcm).

**"When I first received the stimulation, I felt the most intensely joyous sensation"**

After the initial investigation, the team implanted two permanent electrodes connected so that the one in the VC/VS only fires when the other one detects gamma waves in the amygdala. It activates about 300 times a day for 6 seconds, and has been set at a lower intensity, so Sarah doesn't notice it. "We don't want this to be disruptive in her life," says Scangos.

But Sarah did notice a general improvement in her mood when the device was switched on. "It was a gradual process, where my lens on the world changed," she says. "As time has gone on, it's been this virtuous cycle upwards: everything has gotten easier and easier. Hobbies became pleasurable again. Now, a year into therapy, the device has kept my depression at bay."

Scangos plans to use the same approach in 11 more people.

The results are impressive, but we shouldn't assume this will work for everyone, says Keyoumars Ashkan at King's College Hospital in London. "It's possible that everyone's brain circuitry involved in mood is slightly different," he says.

The initial results from the continuous brain stimulation technique were also impressive, but randomised trials found that not enough people got better for the approach to be used widely.

This latest version of brain stimulation is also costly and labour-intensive, requiring days of investigation and two surgeries. Yet the same approach is already used for people with certain forms of epilepsy, who need recordings made in several brain regions to find out where their seizures begin, before they have surgery to destroy the faulty tissue, so there is precedent for such a method.

"If you have the time and effort to investigate an individual, then you could make this therapy very personalised," says Ashkan. "That's what's exciting about this." ■

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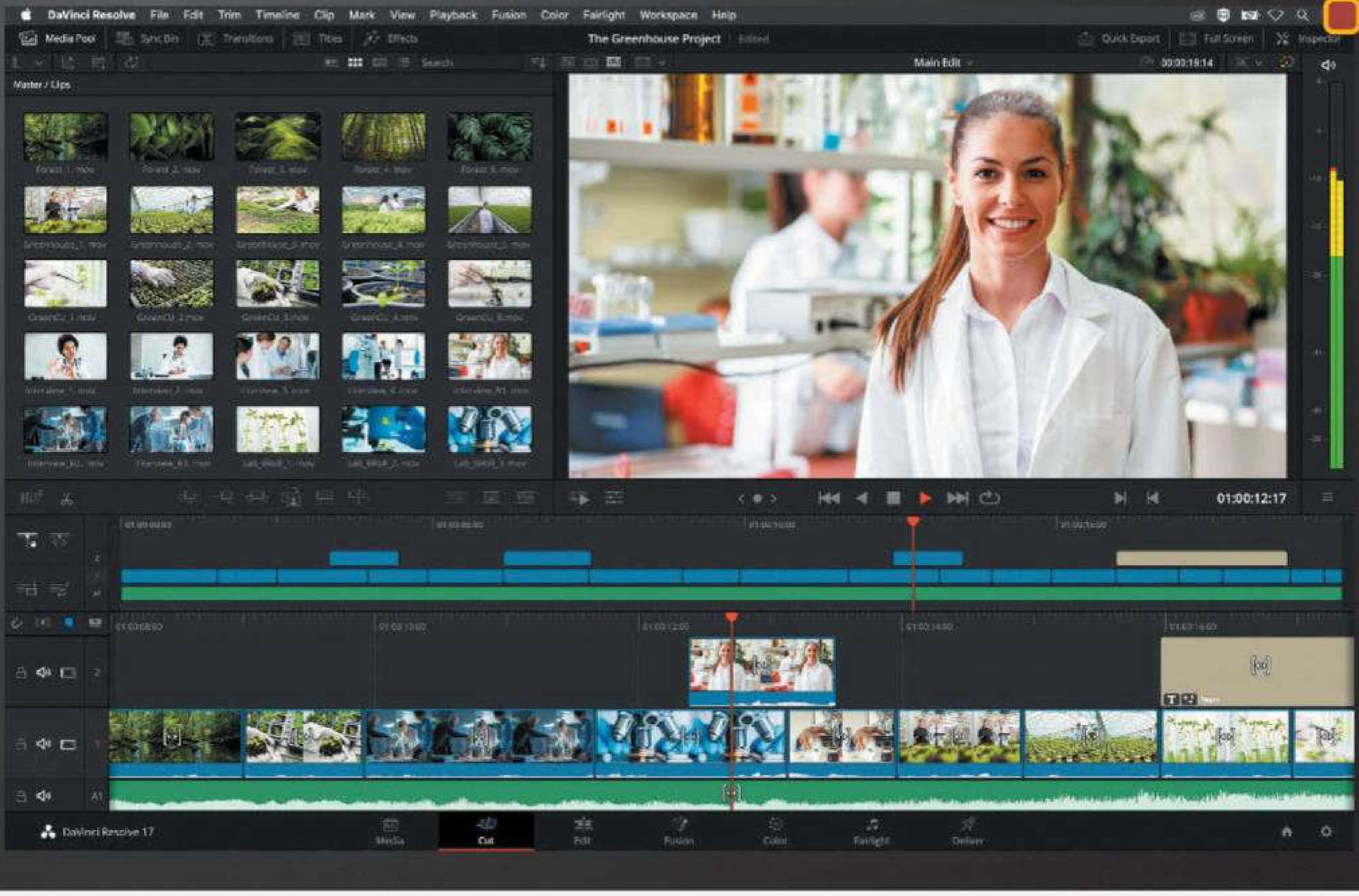

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Computing

# Biocomputers predict the future

## A computer built using single-celled eukaryotes has been put through its paces

**Matthew Sparkes**

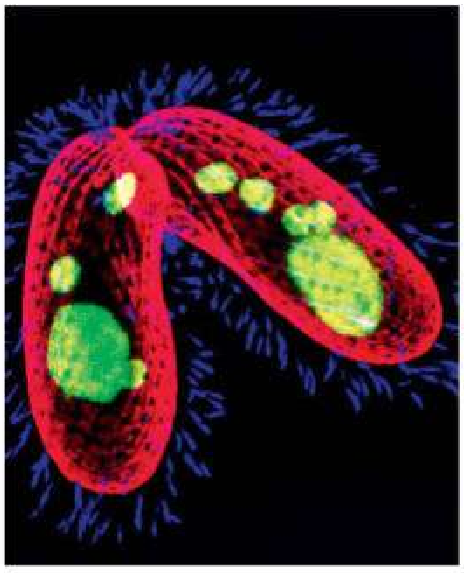
A COLONY of single-celled organisms can function as a biological computer to crunch a series of historical data points and forecast the future. The organisms accurately predict the next step in time series data, such as the size of daily fishing catches of certain species in Japanese waters.

Neural networks are a highly popular form of artificial intelligence that use clusters of mathematically connected nodes to mimic the way that neurons and synapses function in a real brain. The strength of connections between nodes are tweaked over countless training runs in order to teach the network how to perform certain tasks, just as the synapses of the brain reinforce certain patterns when we learn a new skill or memorise new information.

Reservoir computing is a special type of artificial neural network where the strength of connections between nodes remain fixed, so that a given data input will always cause the same chain reactions through the artificial brain. It is the read-out from the reservoir computer, rather than the connections between the nodes, that the AI learns to tweak. This is then used to predict the next step in the data.

Research has indicated that biological material can act as a reservoir, so Masayuki Ushio at Kyoto University in Japan and his colleagues investigated further. They have shown that colonies of a single-celled eukaryotic organism called *Tetrahymena thermophila*, which has cells only 0.1 millimetres long, can function as a reservoir.

**An immunofluorescent image of *Tetrahymena thermophila***



VOLKER STEGER/E. COLE/SCIENCE PHOTO LIBRARY

The team created an incubation chamber and introduced a colony of *T. thermophila*. The chamber was placed under a microscope and a camera took an image of it once a minute, which an algorithm used to automatically count the population of cells.

The chamber and organisms formed the reservoir computer. The input data – in this case, information on the size of catches from fishing vessels – was converted to a series of temperature readings. The incubation chamber's temperature was adjusted accordingly, then changed after a set time interval to the next temperature in the series. Data on the number of cells in the colony was the output. Although the number of organisms grew and shrank, no changes were made to how they interact and the reservoir was left to its own devices as a self-contained unit.

Experiments revealed that the colony size changed predictably if given the same set series of temperature inputs, despite starting from non-identical states. This is a defining feature of a deterministic system and suggests that the set-up had potential as a computer.

"I expected that they should synchronise, but this level of synchronisation was beyond my expectation," says Ushio.

The reservoir used the available data to predict between 15 and 30 data steps ahead, using its predictions as inputs for each step into the future. In experiments, the computer was asked to forecast catch estimates for fishing vessels targeting flatfish or Japanese jack mackerel. The *T. thermophila* predictions were more accurate than those made by mathematical forecasting models at certain time points when compared with real data, says Ushio (bioRxiv, doi.org/gzbr).

"To me, it is not surprising that a biological system can perform computation," says Daniel Gauthier at the Ohio State University – but he says it isn't yet obvious how such a system would prove useful in the real world. ■

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Environment

# People in cities have faced huge increase in heat exposure

**EXTREME heat has been a far greater challenge for urban populations around the world than rural ones over the past 40 years.**

**Cities are particularly vulnerable to heat because of something called the urban heat island effect – a phenomenon where urban areas are much hotter than surrounding rural regions due to their higher concentration of built infrastructure and human activities.**

**Cascade Tuholske at the University of California, Santa Barbara, and his colleagues used worldwide urban population data combined with global fine-resolution maximum air temperature and relative humidity estimates to figure out just how much urban regions have been affected by daily temperatures greater than 30°C between 1983 and 2016.**

**The team combined data for 13,115 urban settlements, including some in rapidly urbanising regions, such as sub-Saharan Africa, the Middle East and southern Asia, that are frequently under-represented in urban studies.**

**Tuholske and his colleagues estimated that global exposure to extreme heat – assessed using a metric that considered the number of individuals affected and the number of days each person was affected – increased by almost 200 per cent from 1983 to 2016.**

**In 1983, there were 40 billion person days of exposure per year, while that figure was 119 billion in 2016 (*PNAS*, doi.org/gzcp).**

"Exposure to extreme heat in cities has increased by almost 200 per cent from 1983 to 2016"

**"This work points to the need for further research on the drivers of heat-health outcomes in urban areas", from the diversity of the urban fabric to mobility, social inequality and temperature-related mortality, says Gabriele Manoli at University College London.**

**The data gathered will be made public to allow others to assess how their communities are being affected by extreme heat, says Tuholske. ■**

**Krista Charles**

Archaeology

## True history of remote Atlantic islands finally told

**Michael Marshall**

**ONE of humanity's greatest journeys has been uncovered. People arrived on the islands of the Azores, in the central Atlantic, about 700 years earlier than thought.**

**"We can clearly identify evidence of early human impact on the islands before the official colonisation by the Portuguese," says Pedro Raposeiro at the Research Centre in Biodiversity and Genetic Resources in Ponta Delgada on São Miguel Island in the Azores.**

**The Azores is an archipelago about 1400 kilometres from the west coast of Europe with nine major islands. It was settled by Portuguese people in the 1400s and is now an autonomous region of Portugal.**

**In sediment in lakes on the islands, Raposeiro and his colleagues found chemicals called stigmastanols and coprostanols. These are only found in the faeces of large herbivorous or omnivorous mammals, which were absent before humans arrived. This telltale sign of occupation was in sediment that formed between the years 700 and 850 AD (*PNAS*, doi.org/gzck).**

**There is no evidence of who the first inhabitants were, but the team suspects the Norse, ancestors of many modern Scandinavians. They possessed the skills and knowledge to sail open seas and are known to have reached other Atlantic islands like Greenland and Iceland.** ▮

The islands of the Azores in the mid-Atlantic may have been inhabited by 850 AD

SANTIAGO GIRALT

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Physiology

## Why a lover's soft touch can awake sexual desire

**Alice Klein**

WESTEND61 GMBH/ALAMY

THE nerve endings in our skin that respond to soft stroking also send signals to the brain to arouse sexual desire under the right circumstances, according to studies in mice and people.

Previous research shows that gentle touch feels good because it stimulates nerve receptors in the skin called C-tactile afferents. These respond to soft, slow stroking and send signals to brain regions involved in emotion and pleasure.

Gentle touch has been shown to play a role in numerous social relationships, including between parents and children. For example, babies' heart rates slow when their parents gently stroke their forearms or shins with soft paintbrushes, suggesting that they find it comforting.

Now, Ishmail Abdus-Saboor at Columbia University in New York and his colleagues have shown that these nerves may also kindle sexual desire when partners touch.

They genetically engineered mice so that nerves in their skin that behave like human C-tactile afferents could be activated by shining blue light on them, rather than by physically touching them.

When they used blue light to artificially activate these nerves, they found that females arched their backs in a similar way to when they were preparing for sex. The mice also experienced a rush of dopamine in their nucleus accumbens, a pleasure centre in the brain.

Female mice engineered to lack these nerves didn't get the same dopamine rush when males tried to mount them for sex, and instead turned aggressive and tried to fight them off. This hints that these nerves convey messages to the brain to "encode a sensation that is necessary for the rewarding nature of sexual touch", write the authors (bioRxiv, doi.org/gx9v).

"It's a fantastic study," says Håkan Olausson at Linköping University in Sweden, who was one of the first to discover C-tactile afferents in human skin in the 1990s. "We don't understand much at all about the neural mechanisms of sexual behaviour, so this is an important finding."

"There are clues that this skin-to-brain circuit is involved in human sexual arousal"

More research will be needed to confirm that the same skin-to-brain circuit is involved in human sexual arousal, but there are emerging clues, says Olausson.

For example, people report feeling erotic sensations when their forearms, inner thighs, necks and foreheads are softly stroked at speeds known to stimulate C-tactile nerves in the skin. Conversely, people who undergo surgery that damages C-tactile nerves are no longer able to experience erotic sensations when their skin is touched.

**Gentle touches can be a source of sexual passion**

Other research shows that a type of sex therapy called sensate focus, in which couples explore touching each other's bodies without intercourse, is useful for treating low sexual desire and erectile dysfunction.

But it is important to note that stimulation of C-tactile nerves only activates sexual desire in certain contexts, says Olausson.

Our brains use other cues to interpret signals from these nerves, so that being touched by a lover has different effects to being touched by a friend, for instance.

Touch may also be sensed as more erotic when couples first get together, whereas it may signal security and comfort in more established couples, says Olausson. "But we don't know how these top-down processes in the brain work yet," he says. ▮

Technology

# Drones are 'sniffing' ship exhausts in European waters

Matthew Sparkes

**The Camcopter S-100, built by Schiebel**

SCHIEBEL

DRONES are being used for anti-pollution missions off the coast of Europe to "sniff" the exhaust fumes from ships and catch operators using illegal fuel.

At the start of last year, the UN's International Maritime Organization introduced legislation to reduce the limit on the percentage of sulphur in fuel used by ships from 3.5 per cent to 0.5 per cent. Certain congested areas, such as the English Channel and the Strait of Gibraltar, have special limits of 0.1 per cent. Emissions of sulphur oxide (SOx) from ships have been found to be a factor in cardiovascular and lung disease and can lead to acid rain.

In a recent operation off the coast of Gibraltar, 294 ships were analysed by drone patrols carried out by the EU's European Maritime Safety Agency (EMSA). Some 27 of the ships were found to be in breach of emissions levels. Other operations around Europe are ongoing.

The Camcopter S-100 drones used in the patrols, which are manufactured by Austrian company Schiebel, can travel at up to 240 kilometres per hour. The 200-kilogram machines, constructed with a carbon fibre skin and 3D-printed titanium parts, are more than 3 metres long and can operate remotely at distances of up to 200 kilometres.

**294**

**ships analysed by a drone patrol in a recent operation**

The drones were used in Malta between 2013 and 2015 at the peak of the refugee crisis and helped locate 30,000 people making risky crossings and coordinate their rescue, claims Schiebel. In 2018, the EMSA contracted a fleet of the drones for emissions monitoring.

The devices are fitted with gas sensors and cameras covering optical and infrared ranges to better detect vessel exhaust plumes. One detector measures SOx and another measures carbon dioxide, and this information can be used to accurately estimate the concentration of sulphur in the fuel being burned. This information is sent to the proper authorities in real time.

Currently, the remote measurements alone aren't admissible as proof for the EMSA to fine those in breach, but the organisation can instruct staff to test fuel directly once a ship suspected to be breaking regulations enters its destination port.

Drone operators are given targets by the EMSA and fly out to the ship's location using the automatic identification system installed on all ships to guide them. Although the drones are able to take off, fly missions and land fully autonomously, current missions are overseen by humans due to the close proximity of flights to shipping.

"We fly there and do the sniffing," says Lubos Sramek at Schiebel. "We approach the vessel from the rear, do the measurement and, after a few minutes, we can fly to check another vessel. It's definitely much more cost effective than if you were to do that with manned helicopters."

The EMSA was unavailable for interview.

Sramek says that, in most cases, the crew members of a vessel will be unaware that they are being tested, despite the drone hovering just metres behind the ship. The noise is comparable to a motorbike, he says, and easily drowned out by noise aboard a ship.

But he warns that there could still be "tricks" being used by ship operators that the inadmissibility of drone evidence leaves unchecked, such as having two fuel tanks and burning cheaper but illegal and dirtier fuel at sea, leaving only compliant fuel for testing in port. ■

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Health

# Lubricating arthritic knees with fluid may help tissues heal

Clare Wilson

**PAINFUL arthritic knees could be treated by injections of a lubricating fluid that mimics the natural version found in joints. The synthetic fluid allows the damaged joints to repair themselves and has been shown to boost cartilage regeneration in rats.**

**Osteoarthritis involves damage to cartilage, a rubbery tissue that caps the ends of bones. Scans of arthritic knees can show bits of cartilage inside the joint that have broken off from the main cartilage tissue. This increases friction inside the joint, leading to a feedback loop that accelerates the damage, says Chuanbin Mao at the University of Oklahoma in Norman.**

**People can have surgery to remove the debris and smooth the remaining cartilage, but this doesn't work very well.**

**Mao and his team focused instead on synovial fluid, the liquid inside joints. Healthy joint fluid contains a large molecule called a lubrication complex, comprised of a backbone of hyaluronic acid that bears feathery subunits called lubricin, as well as lipid subunits. The feathery subunits bind to water molecules, while the entire lubrication complex binds to the cartilage.**

**Mao and his colleagues created an artificial version of the lubrication complex by binding another feathery molecule called PAMPS and a lipid substitute to the same hyaluronic acid backbone. The researchers injected the substance into rats with early arthritis in their leg joints. After eight weeks, the rats' joints looked close to normal when viewed under a microscope (*Nature Biomedical Engineering*, doi.org/gzcs).**

**The cartilage seemed to have regrown, says Mao. "We found that lubrication can help tissue regeneration – that's something new."** ■

Astronomy

# Seeing Earth as another planet

From afar, most of the other planets in our solar system could be mistaken for Earth

**Leah Crane**

TAKING a picture of a far-off world may not be enough to identify what sort of planet it is. We know this because from outside our solar system, every other planet except for Jupiter could be mistaken for Earth.

When planets beyond our solar system, called exoplanets, are discovered via directly taking an image of them, we usually only get two pieces of information from that image: the planet's apparent brightness and its apparent distance from its star.

Dean Keithly and Dmitry Savransky at Cornell University in New York investigated whether, given only those two pieces of information, we are likely to confuse one planet for another. They used our solar system as an example, calculating how often different planets could have properties that would make us think they were Earth from afar.

"Intuitively, you would think planets that appear brighter are bigger, and stars that appear further from their star are further from their star – but that's not quite right," says Nicolas Cowan at McGill University in Montreal, Canada. In fact, a planet's apparent brightness is related to both its size and its reflectivity, and its apparent location is related to both its actual distance from its star and its position on its orbit.

The researchers found that from about 72 per cent of viewing angles, there are locations in Venus's orbit where it could be mistaken for Earth. Mars and Mercury are the next most likely to impersonate our planet – respectively, about 43 and 36 per cent of the angles from which you could view them present an opportunity for confusion. Saturn, Uranus and Neptune can only look like Earth from less than 4 per cent of locations, and Jupiter is so colossal that it never looks like Earth no matter how you view it (*The Astrophysical Journal Letters*, doi.org/gxzc).

Making such a mix-up could be expensive. "The rough cost for a 1.5-day observation of an exoplanet is about $2.4 million," says Keithly. "So if we make a detection and then we want to follow up on it because it seems Earth-like, we could be wasting $2.4 million and time that we could be using to find other exoplanets."

Luckily, the probability of making such a mistake is relatively low. "Although it's true that Neptune or Saturn or whatever can masquerade as the Earth if you catch it at the right place in its orbit, it's actually really unlikely," says Cowan. "A broken clock is right twice a day, but you'd have to get really unlucky to look at a broken clock and have it tell you the right time."

This also isn't an intractable problem – multiple observations of an exoplanet's motion over time will reveal its true distance from its star. Other observations, like the colour of light bouncing off the planet, can help distinguish what kind of world it is too. Still, when we are looking for distant Earth-like worlds, we have to make sure the exoplanets we spot really are as they appear. ▮

**Exoplanets that look Earth-like might actually be more like Venus**

LIMBITECH/SHUTTERSTOCK

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Archaeology

## Source of marble found for huge ancient Greek statue

**ONE of the great statues of antiquity has been connected to its likely birthplace by analysis of its marble.**

**The Colossus of the Naxians on the Greek island of Delos once stood about 9 metres tall, but is now in pieces. One is at the British Museum in London, while the rest are in Greece. The statue's name refers to the island of Naxos, which has been a major source of marble since the Greek archaic era from 800 BC to 480 BC – but it isn't from either of two known quarries of that period.**

**Instead, the marble has the chemical signature of a deposit in another part of the island, found by Scott Pike at Willamette University in Oregon. He will present his results at a meeting of the Geological Society of America on 11 October.**

**His interest in the statue dates from the 1990s, when he tried to check the assertion carved on the base that it was made "of one marble". The British Museum let him take a sample from the right foot, but permission from Greek authorities was difficult to come by.**

**Pike compared the proportions of stable isotopes of carbon and oxygen in the marble to a database of known Greek quarries. "Marble is metamorphosed limestone," he says. "The isotopic signature is related to how that limestone formed." The data suggested the marble of the statue came from somewhere in the south of Naxos.**

**Recently, Pike got permission to do a geological survey there, and he found a line of hills capped by marble not noted on geological maps. The isotopes in the marble are a good match for the statue.**

**There was an abandoned quarry as well, but due to its size and the pattern of extractions, Pike doubts that it birthed the Colossus of the Naxians. Because he didn't have a permit for archaeological sampling, he couldn't date it. He plans to return with such a permit and a lidar-equipped drone to see if he can find other quarries or the roads and slipways used to transport finished statues.** ▮

**Bas den Hond**

"The Colossus of the Naxians on the island of Delos once stood 9 metres tall, but is now in pieces"

Technology

# Norway hooks up to the UK

## The world's longest subsea power cable is now operational

**Adam Vaughan**

**SOME of Norway's breathtaking lakes and fjords house hydropower facilities – and the electricity they generate can now flow through the world's longest sub sea power cable to reach homes in England, Wales and Scotland.**

**The 720-kilometre-long North Sea Link runs from Kvilldal near Stavanger in Norway to Blyth in Northumberland, UK. It will operate at half its potential for three months before reaching its 1400 megawatt capacity, enough to power 1.4 million homes.**

**Blåsjø reservoir (pictured), Norway's largest reservoir and hydrodam, will now be providing electricity to the UK via the link. Power is expected to initially mostly flow from Norway, which generates almost all its electricity from hydro, to Great Britain, where prices are higher. But the link may eventually be used to export electricity from UK offshore wind farms.** ▮

NORTH SEA LINK

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History

# Marie Antoinette's censored love letters read

DURING the throes of the French Revolution, Marie Antoinette expressed her love for Swedish count Axel von Fersen through words that are finally readable 230 years later.

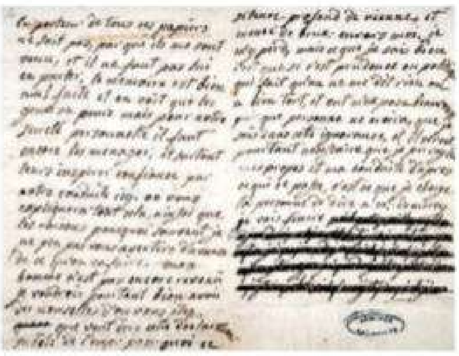
Modern scanning technology has successfully distinguished the ill-fated French queen's ink from that of von Fersen, who scribbled over her text in what was probably an effort to protect his close friend and probable lover, says Anne Michelin at Sorbonne University in Paris.

She and her colleagues investigated 15 letters exchanged between Antoinette and von Fersen from 1791 to 1792 at the request of the French National Archives. While the majority of each missive was readable, certain words or sections had been hidden under heavily penned loops and random letters – Js, Ls and Ts mostly – intended to censor the document. Forensic units of the French National Police attempted to uncover the hidden words in the 1990s, but the technology of the time was lacking, says Michelin.

This year, Michelin's team used X-ray fluorescence scanning to hone in on the compositions of metallic elements like copper, iron and zinc in the letters' inks. Because the various inks used in the letters contained different ratios of these elements, the researchers were able to customise their scanning techniques to decipher the original words buried under layers of ink.

The romantic vocabulary includes terms like "beloved" and "adore" and intimate phrases like "you, whom I love and will continue to love until my…".

**A redacted letter from Marie Antoinette to Axel von Fersen sent during the French Revolution**



CRC

The analyses also resolved the mystery of who had censored the letters. By comparing the compositions of the ink used for scribbling out words and that used for von Fersen's own writing, the researchers confirmed that von Fersen himself had done the redacting (*Science Advances*, doi.org/gx4s).

"There were probably political reasons for keeping the letters," says Michelin, adding that they might have been intended to present a more favourable public image of the queen, who was beheaded by guillotine in 1793. ▮

**Christa Lesté-Lasserre**

**Astronomy**

# Weird white dwarf that is too cold defies explanation

**Jonathan O'Callaghan**

**AN UNUSUAL white dwarf discovered relatively near the solar system is proving difficult to understand.**

**Called DES J2147-4035, the object is about 90 light years from Earth. It is both extremely dim and extremely cool for an object of this kind – probably just a few thousand degrees in temperature.**

**This is cooler than almost any other known white dwarf. Its temperature suggests it is about 10 billion years old, but because our region of the galaxy is composed of much younger stars, DES J2147-4035 is a conundrum (arxiv.org/abs/2109.12707).**

**"It's something we've not seen before," says Kevin Apps, an amateur astronomer in the UK who discovered the object. "To be quite frank, we're not really sure what it is."**

**White dwarfs form when stars like our sun run out of fuel, expelling their outer shells of material and leaving their dense cores behind. These cores then cool over time. DES J2147-4035 is estimated to be at least 70 per cent the mass of our sun, but packed into a sphere smaller than Earth.**

**It was seen by four separate surveys of the night sky, including the European Space Agency's Gaia space telescope, but it had gone unnoticed until now because of the volume of data the surveys produce.**

**Its age is consistent with ancient stars that are found in an outer halo surrounding our galaxy. "But it's part of the disc of the galaxy, which is not thought to contain objects of that age," says Apps. When the star that became this white dwarf first formed, it would probably have been "close to the age of the universe", he says – adding to the mystery.**

**"It could turn out [to be] some unusual type of white dwarf that we haven't seen before," says Apps. ▮**

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**Analysis** Mental health

# To medicate or not?

## Coming off antidepressants increases the risk of depression returning, but even those who continue to take the medications face that risk, finds **Clare Wilson**

PEOPLE who stop taking antidepressants because they feel they no longer need them or because they don't want to be on long-term medications could trigger a relapse into depression, a study has shown. The findings may be taken by some as reason to continue taking such medicines indefinitely – but, in fact, the picture is more complex.

In many high-income countries, the number of people taking antidepressants is at record levels, with an estimated one in 10 people using antidepressants in England. The medicines can cause side effects such as loss of sex drive or appetite and sleeping problems, and can be hard to stop taking.

Some people say that doctors are too willing to prescribe these drugs to people who might be better helped by psychological therapies or by changing their life circumstances, but people who feel they benefit from the medicines sometimes see such sentiments as "pill shaming". The question has become mired in ideological debates over whether modern psychiatry has become overly focused on pharmaceuticals.

There is also confusion over how the drugs work. Most antidepressants are from a class of drug called selective serotonin reuptake inhibitors (SSRIs). For a long time, it was thought that people experiencing depression have low levels of the brain signalling chemical serotonin, which SSRIs restore. If that were so, it would make sense that some people would need antidepressants for life.

But it now seems that this "chemical imbalance" theory of depression is wrong – and we still don't know the real biological explanation for the causes of depression, or how SSRIs alleviate it in some cases.

The latest study doesn't answer that question, but it should provide some insight for people who are weighing their options when it comes to using these medicines. The study looked at 478 people in the UK on an antidepressant who were considering stopping taking the pills. About half were chosen at random to continue, while the rest were given placebo tablets instead of their usual pills.

**39%**

**People who had depression return while on antidepressants**

After one year, 56 per cent of people given a placebo saw their depression return, compared with 39 per cent who continued taking the medicine (*NEJM*, doi.org/gxw7).

Put another way, for every 10 people weighing up the decision of whether to stop taking antidepressants, about four would relapse and just over four would stay depression-free, whatever course they decided to take.

**Antidepressants can cause side effects such as sleeping problems**

THUNDERSTOCK/SHUTTERSTOCK

For the others, stopping the medicines may lead to a relapse.

"Although the risk of relapse is increased [by stopping], it's not increased hugely over continuing to take antidepressants," says Tony Kendrick at the University of Southampton, UK, one of the authors of the new study.

The findings suggest that either decision is reasonable, and the choice people make depends on their personal preferences, he says. For some, the risk of experiencing depression again would be too great to stop taking their prescribed antidepressants, while others may have a stronger preference not to be on long-term medication.

Kendrick stresses that anyone wishing to stop taking antidepressants should do so under their doctor's guidance. People who stop taking antidepressants suddenly can experience temporary withdrawal symptoms including low mood and agitation, which can be confused with a relapse of their depression.

The problem of withdrawal symptoms keeping people stuck on antidepressants has recently become more recognised. Medical bodies used to advise that people could taper their intake of these medicines by just taking half their normal dose for two weeks. The UK's Royal College of Psychiatrists now says the tapering period can take months or longer, especially if someone has been on the medicines for years. People in this new study were generally weaned off by being given a half dose for the first month and a quarter dose during the second month.

Whatever people's decision, it is good news that from now on, it can be more informed by evidence, rather than driven by ideology. ▮

Environment

# It will soon be easier to run trials testing gene-edited crops in England

**Adam Vaughan**

LAW changes later this year will make it easier to run field trials in England on crops that are gene-edited for environmental and nutritional benefits.

The UK government, which announced the move last week, also said it plans future legislation so gene-edited crops and livestock that mimic the effects of natural breeding are treated differently to genetically modified (GM) ones, a step that would pave the way to gene-edited food being sold in UK supermarkets for the first time.

Gene editing sees the DNA of an organism precision-targeted, often using CRISPR technology. This means gene editing doesn't involve inserting whole genes or genes from other species, which other GM crops may carry. A recent example tested in the real world involved wheat edited to lower the risk of a carcinogenic compound forming when bread made from the wheat is toasted.

Proponents say that such editing of crops simply speeds up natural breeding techniques.

The UK approach signals a post-Brexit divergence from the European Union, which regulates gene-edited organisms in the same way as GM ones, effectively banning them from being grown and sold. The UK carried over that regulation when it left the EU.

Last week's first step away from that regulation is a modest one following a consultation. The government will lift the licensing hurdles that laboratories face when starting a field trial of gene-edited crops, a crucial exercise to see how well they grow in more realistic conditions.

**Non-gene edited wheat growing in a field in the UK**

SHUTTERSTOCK/AMANIA

The change in England, due to be undertaken using government legislation before the year is out, should save about £10,000 per trial and cut a two-month wait before trials can begin.

Wendy Harwood at the John Innes Centre in Norwich, UK, says: "We're hoping it will make it easier to have a look at these plants in the field, which will enable scientists to identify which ones to take forward."

However, researchers will still have to notify the Department for Environment, Food & Rural Affairs, and Scotland and the rest of the UK may decide different rules. The UK government believes the rule changes are less important than the statement of intent they send, to unlock investment in gene-edited crops.

"It's vitally important. It applies to research and development only, but it's a first step," says Nigel Halford at Rothamsted Research, UK, which is trialling gene-edited wheat.

The rule changes won't allow gene-edited food to be sold. Yet that may change too. The UK government said it plans a longer-term review of GM regulation. But the public may be unwilling to buy the foods. Two decades ago, protesters ripped up trials of GM crops, and opponents called them "Frankenfoods". Among the 6440 responses to the new consultation, 88 per cent of individuals and 64 per cent of businesses said they believed gene-edited crops should continue to be regulated as GM organisms. ▮

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Astronomy

# There may be an exoplanet orbiting three stars at once

**MOST planets we have found orbit only one star – a few orbit two, but so far we have never spotted one orbiting three stars simultaneously. Now, researchers have seen hints of a young world doing just that.**

**These hints come from a stellar system called GW Orionis, which consists of two stars orbiting one another at about the same distance that Earth sits from the sun, and a third circling those two about eight times further away. Encircling all three stars is a disc of dust and gas separated into three rings.**

**There is a huge gap – about 15 billion kilometres across – between the innermost ring and the others. Some astronomers interpret this gap as having formed when torque from the gravity of the three stars ripped the disc apart, but Jeremy Smallwood at the University of Nevada, Las Vegas, and his colleagues have determined that it is more likely a planet carved it out.**

**They performed 11 simulations of the stars, including the gas in the disc. The dust wasn't included in the simulations, as it is expected to follow the structure of the gas. This showed that without a giant planet, torque from the stars didn't lead to separate rings. However, inserting a planet about the size of Jupiter reproduced the observed gap. When the gap filled in over time, the planet simply carved a new one (arxiv.org/abs/2109.09776).**

**"We haven't observed the planet directly, but there is some evidence that a planet is shaping this gap," says Smallwood. If it is there, this would be the first world ever found that orbits three stars, and there may even be a second, smaller planet between the outer two rings.**

> "We haven't seen it directly, but we have evidence a planet is shaping a gap in its host stars' dust rings"

**Confirming this will be hard. The larger world would be far from the stars and have a tilted orbit, making it tricky to detect using the usual method, which relies on a planet blocking a star's light when passing in front of it. The best way to confirm its existence would be a direct image, but the system is more than 1000 light years from Earth, so that would be tough, too.** ▮ Leah Crane

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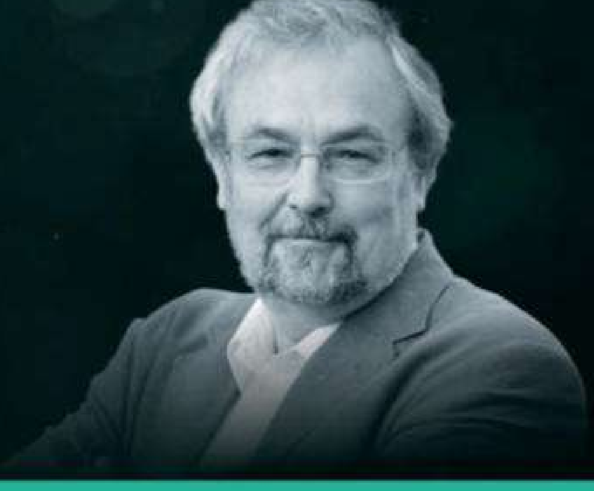

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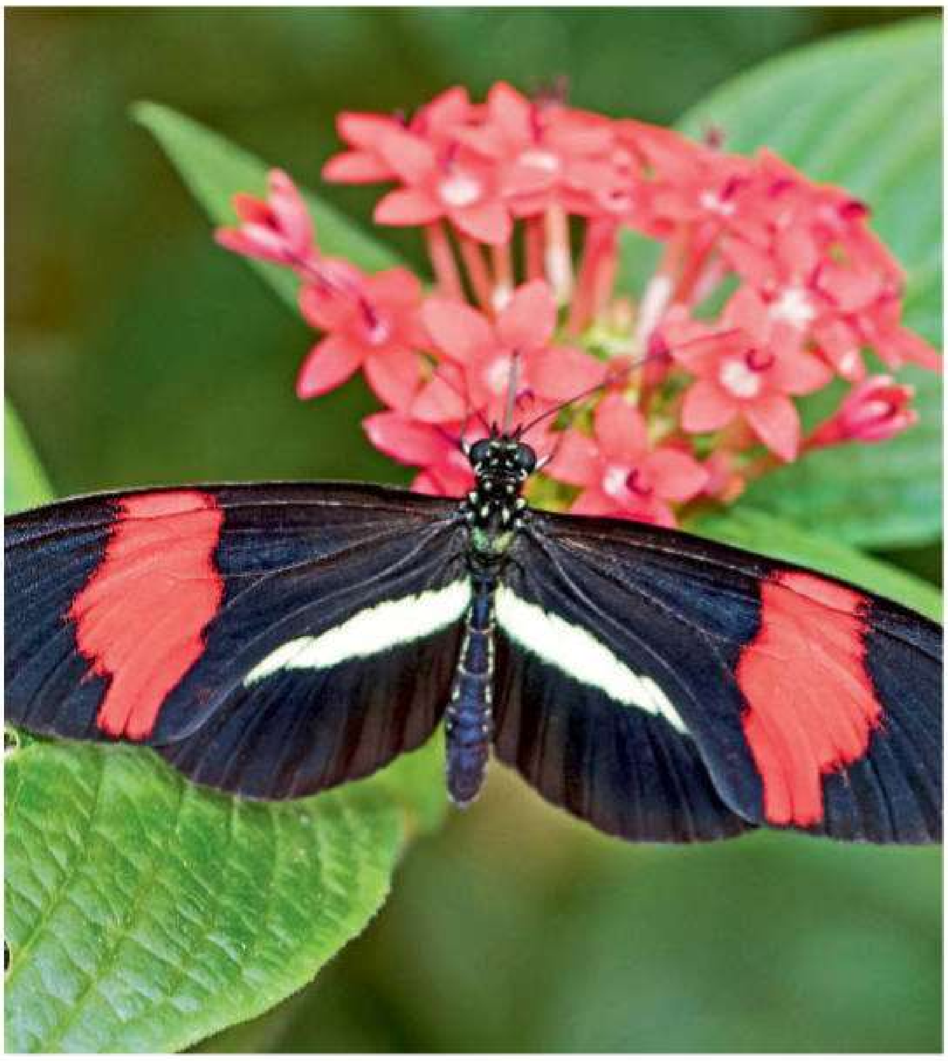
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**Animal behaviour**

## Butterfly shows rare ability of seeing two shades of UV

**FEMALE red postman butterflies see an extra colour in the ultraviolet part of the light spectrum that even the males of their species cannot.**

**While many animal species can see one colour of UV, making out multiple shades in this part of the spectrum is rare. Susan Finkbeiner at California State University, Long Beach, and Adriana Briscoe at the University of California, Irvine, trained 80 *Heliconius erato* butterflies, an American species, and 120 butterflies from two other species to sip from a feeder placed on a light source that was tuned to a specific UV wavelength.**

**After training, the butterflies were allowed to fly within an enclosure where two UV light sources were each tuned to a different UV colour. The *H. erato* males and all the butterflies of the other two species flew towards whichever light was the brightest. When the two lights were equally bright, they landed on the light that had a watered-down honey reward on it about half the time, showing that they couldn't tell the difference between the two UV colours, the researchers concluded.**

**The *H. erato* females correctly chose the UV colour associated with the honey reward under every testing condition, even if the other UV light was 15 times brighter (*Journal of Experimental Biology*, doi.org/gx2p).**

**This suggests a division of labour by sex, perhaps similar to that seen in squirrel monkeys, where only females can differentiate between red and green, making them specialists in finding ripe fruit for their group.** Madeline Bodin

**Solar system**

## Deep gorges on Mars sign of potent floods

FLOODS may have been far more important on ancient Mars than thought. The Red Planet is criss-crossed by valley networks that once held rivers, and the deepest of them seem to have formed quickly from cataclysmic flooding.

Up until about 3.5 billion years ago, many of the craters on the Martian surface were full of water. Timothy Goudge at the University of Texas at Austin and his colleagues mapped out how often those lakes overflowed, creating ravines as they did so.

Generally, we assume that riverbeds are carved out by slow erosion, but some large floods on Earth have been seen to create canyons quickly and violently.

The researchers found that Martian ravines that formed rapidly from the overflow of lakes were rare – they only represented about 3 per cent of the total combined length of all the valleys in the areas examined. But with an average depth of 170 metres, those ravines were more than twice as deep as the other valleys on average, meaning they were responsible for a huge amount of erosion (*Nature*, doi.org/gx25).

"If you look at the landscape and map these valleys out, they look pretty sparse, but when you look at the volumes, what you see is that these catastrophic outlet canyons actually represent about one-quarter of the total valley erosion," says Goudge.

That means these valleys were probably far more important to the landscape on ancient Mars than we realised, redirecting the flows of the other rivers as water poured into the new canyons.

"Our understanding of how much water was available at the surface and for how long really feeds into our understanding of how Mars might have been able to sustain life or evolve life," says Goudge. **Leah Crane**

**Natural disasters**

## Mental decline link to Japan's tsunami

THE earthquake and tsunami that struck Japan in March 2011 killed 20,000 people and uprooted many more. Now there is evidence the disasters and disruption in their wake may have contributed to cognitive decline in some people.

Koichiro Shiba at Harvard University and his team analysed data from a study of people in Japan aged 65 years or older. They focused their efforts on data taken from Iwanuma in Miyagi Prefecture, which was severely hit by the tsunami. About 3350 adults with an average age of 73.2 took part in the initial survey, seven months before the disasters, and were surveyed again in a follow-up 2.5 years later. In a follow-up 5.5 years after the earthquake, 2664 of the adults took part.

The team found that those who lost their home during the disaster typically saw an increase in their rate of cognitive decline and that low-income individuals, who were also more likely to be older, unmarried and less well-educated, were more vulnerable to this (*Science Advances*, doi.org/gx23).

The latter may be because these people have been in temporary accommodation for longer and faced greater social isolation, says Shiba. The team found that the loss of a loved one in the disaster wasn't associated with an increase in the subsequent rate of cognitive decline. Shiba says it is unclear why. **Jason Arunn Murugesu**

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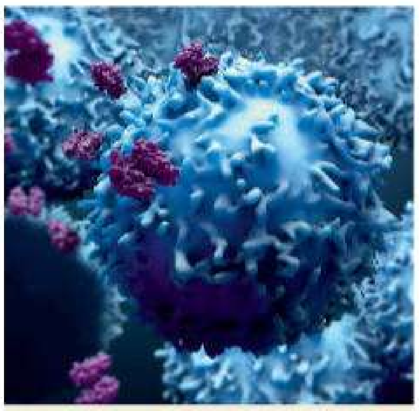
## *Really* brief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### Mapping proteins may aid cancer fight

**A map of how proteins interact in cancer highlights possible new therapies. The map revealed 771 protein interactions in head and neck cancer, 84 per cent of which weren't previously known. If these interactions are critical for tumour growth, drugs that disrupt them could slow cancers (*Science*, doi.org/gx2f).**

### UK dinosaur was like heron from hell

**Two 9-metre-long carnivorous dinosaur species that roamed the UK 125 million years ago have been named. One has been dubbed *Ceratosuchops inferodios*, which translates as the "horned, crocodile-faced hell heron". The second is *Riparovenator milnerae* (*Scientific Reports*, doi.org/gx2g).**

### Test to reveal if you had an unborn twin

**About one in eight people had a twin embryo that didn't survive to term, and in future a DNA test might reveal if you are in this group. This is because identical twins carry certain epigenetic DNA changes that aren't seen in people who didn't have a twin (*Nature Communications*, doi.org/gx2h).**

Coronavirus

## Jab priority by race may have saved lives

PRIORITISING people of colour for covid-19 vaccines when they were in short supply would have prevented more deaths than rolling out the vaccine purely by age groups, a US modelling study has suggested.

When the coronavirus vaccines were in limited supply earlier this year, US authorities, along with most high-income countries, advised offering them first to healthcare workers, care home residents and then to people in descending age order. Age is one of the biggest determinants of risk from covid-19, but US and UK studies show that people of colour are also at higher risk – perhaps because they are more likely to live in crowded housing, have worse healthcare access and work in jobs with more exposure to the virus.

Elizabeth Wrigley-Field at the University of Minnesota and her team checked if a roll-out taking account of people's race as well as their age would have avoided more deaths. They looked at California and Minnesota and modelled various scenarios. They found that offering vaccines to groups of people defined by race and age bands, rather than just by age, would have avoided more risk of death (*Science Advances*, doi.org/gmx88s).

As targeting people by race could have been discriminatory, health services should have organised vaccine distribution by combining age bands with where people live, in order to target neighbourhoods that have high numbers of people at risk of covid-19 because of race, says Wrigley-Field. **Clare Wilson**

Technology

JORDAN MANSFIELD/GETTY IMAGES

## AI can tell if it is going to rain on you in the next few hours

**AN ARTIFICIAL intelligence system created by DeepMind and weather experts at the Met Office can say if it will rain in the next hour or so more accurately than other methods.**

**UK-based firm DeepMind has had success with neural networks trained to play the game Go and to investigate protein folding. It has now applied its deep-learning approach to short-term rain "nowcasts". These usually focus on the next 2 hours of weather and are used by organisers of events, such as the Wimbledon tennis contest (pictured), flood warning systems and the aviation industry.**

**The researchers trained a neural network on weather data from 2016 to 2018 and tested it using data from 2019. The resulting model can make predictions for areas up to 1536 kilometres by 1280 kilometres and give the chance of rain in a given 1km by 1km area from 5 to 90 minutes ahead using 5 minutes of historical data (*Nature*, doi.org/gmx6dc).**

**The team compared predictions from the DeepMind tool with those from two existing tools. DeepMind claims that in a blind study of 50 meteorologists from the UK's Met Office, its AI model was ranked first for accuracy in 89 per cent of instances. Matthew Sparkes**

Marine biology

## Cleaner wrasse could have theory of mind

FEMALE cleaner fish are sensitive to what their partners can and can't see while working on client fish. This means they may have theory of mind – an awareness of other's perspectives often linked with humans and other primates.

Cleaner wrasse (*Labroides dimidiatus*) typically work in male-female pairs to "clean" client fish by eating their dead skin cells and skin parasites. The wrasse prefer to eat the mucus made by client fish, but the clients can react to this by terminating the relationship – leaving the cleaners without food.

If one of a fish pair cheats by eating mucus, this may leave both without food. If a male cleaner fish knows his partner has cheated, he can punish her, says Katherine McAuliffe at Boston College in Massachusetts. McAuliffe and her team wondered whether females had developed ways to cheat without the males knowing.

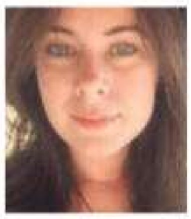
In an experiment, the researchers showed that female cleaner fish are more likely to cheat when partners are out of view. This suggests the wrasse have evolved cognitive abilities to find solutions to problems on a par with animals such as primates (*Communications Biology*, doi.org/gx3d). **Krista Charles**

**MEDECINS SANS FRONTIERES**
**DOCTORS WITHOUT BORDERS**

Above: An MSF team perform surgery in one of three operating theatres at Boost hospital, Lashkar Gah, Helmand province. *Photograph © Tom Casey*

# AFGHAN CRISIS APPEAL

## "Fighting in Afghanistan had been intense since May, but in August the situation got progressively worse."



**SARAH LEAHY**
**PROJECT COORDINATOR**

"For a time, the frontlines ran right by our hospital in Lashkar Gah. We were located in between strategic buildings and rockets would be going over the hospital, explosions occurring and bullets hitting the buildings all the time. We were exposed to the crossfire and twice we were hit by rockets.

It was very intense, but through all the fighting we carried on working. It's a huge hospital, one of MSF's biggest projects, and is an absolute lifeline in Helmand province. We have nearly 1,000 Afghan staff, an emergency room where we treat more than 500 patients a day and a maternity ward with an average of 60 deliveries a day.

During the fighting we were getting 30 to 40 people in for surgery each day with bullet wounds and injuries from shelling and explosions.

Many people who needed medical care struggled to reach us. People were forced to wait at home until the fighting subsided, while others were caught up in crossfire on their way to hospital. People would be coming to see us for pneumonia, then get caught up in the fighting and arrive with a bullet in the shoulder or the leg. Roads and bridges had been bombed, so what should have been a 40-minute journey to hospital took four hours. There was no fuel, but people were coming on foot from all over the province, on pushbikes with pregnant women, all in 48-degree heat.

The health system in Afghanistan has essentially collapsed. It wasn't in great shape in the first place, but now the situation is desperate. That's why it's so important that MSF is still there, conducting surgeries, helping women give birth, giving people the basic, lifesaving healthcare that they need. It's vital that Afghanistan and the people who need our help are not forgotten."

Since the change of government in August, our teams have continued providing medical care to the people of Afghanistan. In five locations across the country, our teams are treating emergency trauma cases and providing lifesaving medical care.

**Thank you.** It's your financial support that enables us to continue working in Afghanistan and in neighbouring countries. We couldn't do it without you.

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**Culture columnist**
**Simon Ings** enjoys an environmental documentary p32

Comment

# Climate influencers

Many people have a disproportionate impact on climate change – here's how to harness that power, write **Kimberly Nicholas** and **Kristian Steensen Nielsen**

WE ARE often encouraged to reduce our impact on the climate, but the truth is that some people's actions have greater effect than others. The super-rich "polluter elite" immediately come to mind. But if, like us, you are college educated, have a white-collar job, live in a prosperous area or earn more than $38,000 (£28,000) a year, you are of "high socio-economic status" and you have disproportionate power and responsibility in relation to averting catastrophic climate change.

This group makes up the top 10 per cent of income globally and causes half of the carbon pollution emitted by households. The majority of this is created through frequent and long-distance travel by plane and car, followed by home energy use. Reducing this overconsumption is key to halting global warming.

But as we show in a new study (*Nature Energy*, doi.org/gmx9cg), there are four other critical roles through which the 10 per cent leave an outsized climate footprint, and through which ambitious climate action can be promoted or hindered: where their money is invested, how they communicate with and behave around other people, the actions they press for in organisations, and as citizens. These are the ways individuals can most affect firms, governments and society.

If you have a pension, or savings in investment accounts at a major bank, chances are that you are financing climate destruction via loans and investments to expand and support fossil fuel pipelines and power plants. To support climate stability instead, shift your money from banks, pension funds and stocks that still finance fossil fuel companies and support campaigns to get organisations to divest from fossil fuels.

Social influence increases with status, but we all influence those around us. We can use this with family, friends, neighbours and colleagues to promote climate-friendly aspirations and norms in our networks and communities. One simple way to wield influence is through shifting social media posts away from celebrating conspicuous consumption, and towards simpler pleasures of time with family and friends and in nature closer to home.

You can also press for climate action in the organisations where you work, play or study. Speak up for and drive policies for decarbonising industries and supply chains, and advocating for philanthropy. The recent Project Drawdown guide *Climate Solutions at Work* offers practical advice on how to make every job a climate job, while the Science Based Targets initiative sets pathways for companies to do their fair share to meet the goals of the Paris Agreement.

As citizens, voting is a powerful climate action. Those of us lucky enough to live in the 18 per cent of countries that meet high democratic standards should use this power. Until now, political access and influence have mainly been used to promote fossil fuels and other corporate interests in policy-making. This can change by making climate a leading political and election issue through social mobilisation and lobbying, and by holding representatives accountable for their climate votes, especially as many report feeling little pressure from their constituents to take climate action.

Recommendations for personal climate actions are too often misdirected towards those with low potential impact, like recycling, or presented as being universally applicable, when it is in fact the well-off who most need to change their behaviour to cut global emissions. The way forward is to recognise that wealthier people have both special agency and responsibility to take action to turn the ship around. ▮

MICHELLE D'URBANO

Kimberly Nicholas is the author of *Under the Sky We Make* and Kristian Steensen Nielsen is at the University of Cambridge

#FactsMatter

# A maize meme mystery

An image implying that squirrels avoid genetically modified corn has gone viral on social media, but its origins are extremely dubious, writes **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

## James's week

### What I'm reading

*I am going old school and delving into some Victorian horticultural texts, which sadly is what I do for fun.*

### What I'm watching

*I am currently engrossed in* Nine Perfect Strangers *on Amazon Prime. It is set in California, but the plants in the landscape reveal it is really filmed in Australia.*

### What I'm working on

*I am working on a few TV projects, including a new global farming documentary for the BBC.*

This column appears monthly. Up next week: Chanda Prescod-Weinstein

I FIND the enormous potential of social media to share scientific knowledge across the planet fascinating. In particular, its ability to empower people to exchange anecdotal observations, which can lead to some of the most important discoveries, is a wonderful thing. So when a viral meme claiming to show the results of a student trial on genetically modified corn kept popping up on my feeds last week, it really fired up my curiosity.

This photograph, which has been shared thousands of times, shows two ears of maize stood side by side. The one on the left of the picture, labelled GMO, is almost fully intact, while the one on the right, labelled organic, is largely stripped of kernels. Above this, bold black font announces that this was the result of an experiment run by students in England that compared the impact of park squirrels munching on the two cobs. The implication of this meme is that animals have some kind of innate avoidance of GM corn, which some suggest means that humans shouldn't eat it either.

Whatever we choose to infer from this image, as historically there have apparently been zero studies on animal feeding preferences in relation to GM food versus conventional varieties, I thought it would be a fun exercise to look into this in detail. Could the students behind it be flagging up a novel observation that merits further investigation, or is this yet another image that we should add to the rather large pile of junk science memes out there?

My first stop was to go straight to the academic databases to check if this study had been published. You would think that even if this were an informal student trial at a university, a letter to an editor might pop up at the very least. Yet this didn't seem to be the case.

Perhaps it was a school project then? However, if so, where did the GM ear of maize come from? Currently, these can't be legally grown in the UK, which would make finding one tricky for a group of schoolchildren, so it struck me that I really needed to take a closer look at the origin of the photo.

Through a reverse image search using a range of different internet search engines, I found that the photograph actually dates back to 2012, as part of a collection of very similar images posted by a farmer in South Dakota to an online photo-sharing platform. This attribution was echoed by at least one online news article from 2013, in which the farmer in question was interviewed after the post had initially gone viral.

> **"The implication of the meme is that animals have an innate avoidance of genetically modified corn"**

So according to its digital paper trail, this wasn't a photo from a trial run by students, nor was it carried out in a park or even in the UK. In fact, at some point, it appears an alternative backstory has been fabricated around this image, which isn't a great sign. While obfuscation of its actual origin might raise a considerable red flag, it doesn't necessarily mean the results the image claims to show should be automatically refuted. So could this still be an interesting finding that warrants further investigation?

Well, let's just imagine that the viral photo does indeed depict what it claims to, as it is always nice to assume good faith. A single side-by-side comparison of two corn varieties wouldn't be quite the neat test it might appear to be.

That's because there are a huge range of other distinguishing factors that could separate two randomly selected corn varieties aside from their method of breeding. Some types may contain higher levels of sugar or lower levels of fibre, for example, which could easily make them more palatable to squirrels. Without controlling for these, it would be very tricky to place much faith in the results.

What's more, by the image's own admission, the trial isn't testing the single variable of the genetics of the variety, but also the growing method. With the non-GM corn having been grown using "an old rural style", it would almost certainly have been cultivated using a different regimen of fertilisers, crop treatments and irrigation, most likely on an entirely different farm, potentially in a totally different part of the country, even the world. Not a great like-for-like comparison, then.

Finally, it almost goes without saying that the image depicts a single experiment involving two cobs and potentially just one squirrel. There is no guarantee that if it were repeated, it wouldn't show the direct opposite results, even with the same furry participant.

So until a larger trial with a more carefully controlled design comes along, we will just have to hold our breath until we learn more about the science of crop preferences of squirrels. What we can say, though, is that it would be very difficult to describe this meme as a source of solid scientific information, despite how it frequently and confidently it is cited online. ▮

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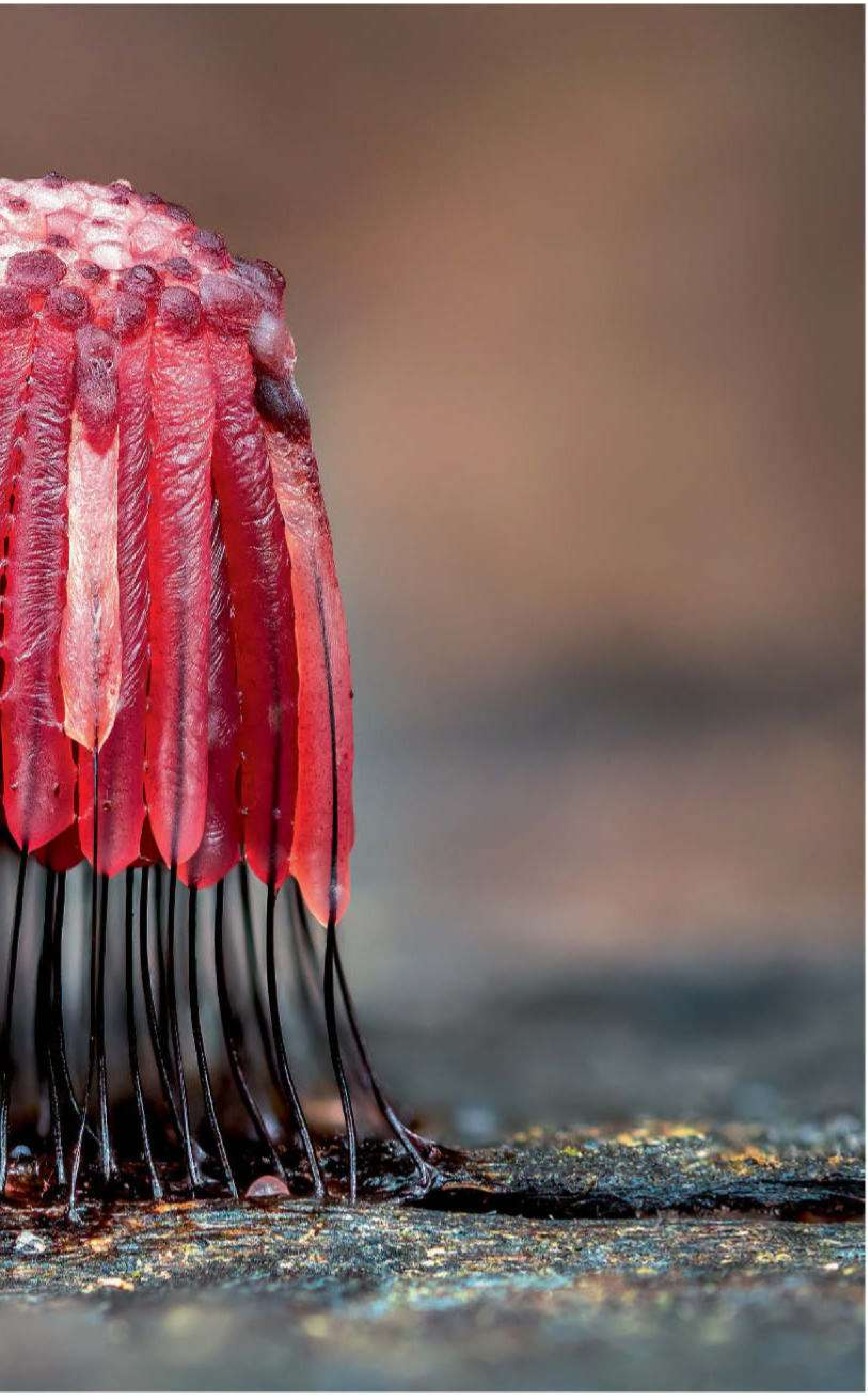

# Sublime slime

**Photographer Barry Webb**

A WOODLOUSE feasts on a gelatinous slime mould in this mystifying shot by photographer Barry Webb. The image, taken in Buckinghamshire, UK, was the overall winner in this year's *New Scientist* Photography Awards, as decided by public vote.

Slime moulds are organisms that can exist as single cells, but clump together to form larger, moving bodies, either to reproduce or hunt for food. Once considered a type of fungi, members of this diverse group of organisms are now classed as protists, an enigmatic and diverse kingdom that includes amoebas.

This particular slime mould, of the genus *Stemonitis*, isn't yet fully developed and stands only 15 millimetres tall. Webb took 19 shots, each focused on a slightly different part of the scene, before stacking the images to get the final photo. This is necessary because slime moulds are usually so small, he says – although some types can grow to several metres.

"I had never seen a woodlouse feeding on a *Stemonitis* slime mould before and thought that it would make an unusual and captivating image," says Webb, who also won the award's The Natural World category.

He says he is pleased that "the ethereal beauty of slime moulds" is being shown to a wider audience.

**Gege Li**

*You can find more of Barry Webb's photography at barrywebbimages.co.uk*

## Editor's pick

### On the paradox of time flowing only one way

**25 September, p 34**

*From Paul Bannister, Canberra, Australia*

**Paul Davies raises a critical point on the paradoxical arrow of time. Surely, the process of measurement at the quantum level defines a direction of time. Indeed, one could also extend this to note that the discussion about the (theoretical) reversibility of gas mixing is dependent upon perfect knowledge of state, which quantum mechanics also tells us isn't possible.**

**Do these add to define both a direction of time and a link between the classical concept of entropy and the quantum world? As someone who is rooted in thermodynamics, it seems entropy gets short shrift in cosmological ponderings.**

### Solving the recycling issue requires more thought

**25 September, p 18**

*From Frank Adam, Prestwich, Greater Manchester, UK*

Any charges for removing rubbish just create fly-tipping and higher costs. A better way is legislating so those authorities not already using multi-bin sorting for recycling take it up. Supermarkets can also follow the example of a Canadian chain that has recycling bays to sort waste and repay deposits for returned bottles, tins and paper.

*From Georgina Skipper, Weymouth, Dorset, UK*

With the recent emphasis by the UK government on "nudge" techniques to modify behaviour, I wonder why there has been little research into the motivation behind recycling.

I live in Weymouth. Until 2011, we achieved 70 per cent recycling. Then our waste service merged with another authority, whose recycling rate was only about 30 per cent. Ten years later, the combined recycling rate is back up to 60 per cent. The question is, why was one area so keen to recycle while the other took years to convince? Surely, if the analysts could work this out, we could motivate the country to recycle.

*From Larry Stoter, The Narth, Monmouthshire, UK*

A major problem in trying to recycle plastic is that it is often far from clear if it can be recycled. My local authority can't recycle the large bags in which bird food is delivered, but if I go a few miles to the next local authority, it can be.

Then there is the problem of recyclable and non-recyclable packaging being mixed – for example, recyclable plastic bottles covered with a non-recyclable plastic wrap. Most people don't have the time or inclination to carefully sort through all this packaging and pull it apart.

Legislation is required, not only to standardise recycling across the UK, but to ban mixed packaging and to get manufacturers to move towards 100 per cent recyclable packaging.

### Why food waste might be an intractable problem

**25 September, p 42**

*From Perry Bebbington, Kimberley, Nottinghamshire, UK*

Of course we waste food. Since the green revolution in the mid-20th century, we have striven to ensure we have plenty of all kinds of food. We can't have "just enough" because it is difficult to predict how much of each type of food we will need and even harder to know whether crops in a particular year will produce in abundance or if they will fail.

Given the only way to ensure we have plenty is to aim to produce too much, waste will inevitably follow from that. Buying lettuce in different-sized bags won't make the slightest difference.

### Orcas may have declared war on the fishing fleet

**18 September, p 17**

*From Peter Prescod, Lehigh Acres, Florida, US*

You wonder why orcas have started ramming boats off Gibraltar. Has any thought been given to the possibility that these animals may be perceiving the boats as competitors for the tuna they eat and are attempting to drive them away?

### Mars life more likely to thrive in dark depths

**4 September, p 9**

*From David Pitcher, Auckland, New Zealand*

You report work on the viability of life that relies on photosynthesis in the sheltered zone of caves on Mars. As life has evolved to process energy from chemosynthesis on Earth, surely life on Mars is more likely to exist without any need for photosynthesis, especially given the proportionate lessening of the sun's power at that distance.

Nick Lane, in the book *Oxygen: The molecule that made the world*, makes a plausible case that photosynthesis was a process that evolved later, a mutation from an older, chemosynthetic life form.

### Is it time to give the military robots a break?

**18 September, p 11**

*From Paul Tothill, London, UK*

David Hambling's interesting article on firing weapons from autonomous warships mentioned that any strike from an uncrewed ship mandated human control.

Given that the last drone strike in Afghanistan was planned and executed by humans, resulting in the deaths of 10 civilians (seven of whom were children), maybe it is time to let the machines take control? The gods help us!

### More thoughts on the shift to a net-zero way of life

**4 September, p 34**

*From Lachlan Jones, Brisbane, Australia*

In one part of your illuminating article on a net-zero life, you mention the fictional Isla planning a holiday that avoids the "moral opprobrium" of long-haul flights in favour of a train tour in Norway. While I agree that travelling by train is preferable to flying within Europe, I can't help but wonder about the future of nature reserves in Africa, South-East Asia or South America if tourists stopped visiting because of aviation emissions.

*From Mark Haden, Vancouver, Canada*

Your article missed a vital aspect of our transport future. A person on a pedal bike is the most efficient form of transport, as defined by distance travelled per unit of energy consumed. An extra bonus could be added to this equation if the person eats a plant-based diet. Plants fuelling bicycle transport is the ultimate in efficient travel.

*From Rachael Padman, Newmarket, Suffolk, UK*

Heat pumps probably are the way forward, especially in new-build homes. However, in existing housing, the payback time is long. And like many green technologies, the first things the user will notice are a rise in both installation and running costs over the status quo, an increase in noise and a decrease in convenience. Heat pumps' advantages over direct electrical heating will also decrease as we decarbonise the electricity supply. We need to be upfront about this. ■

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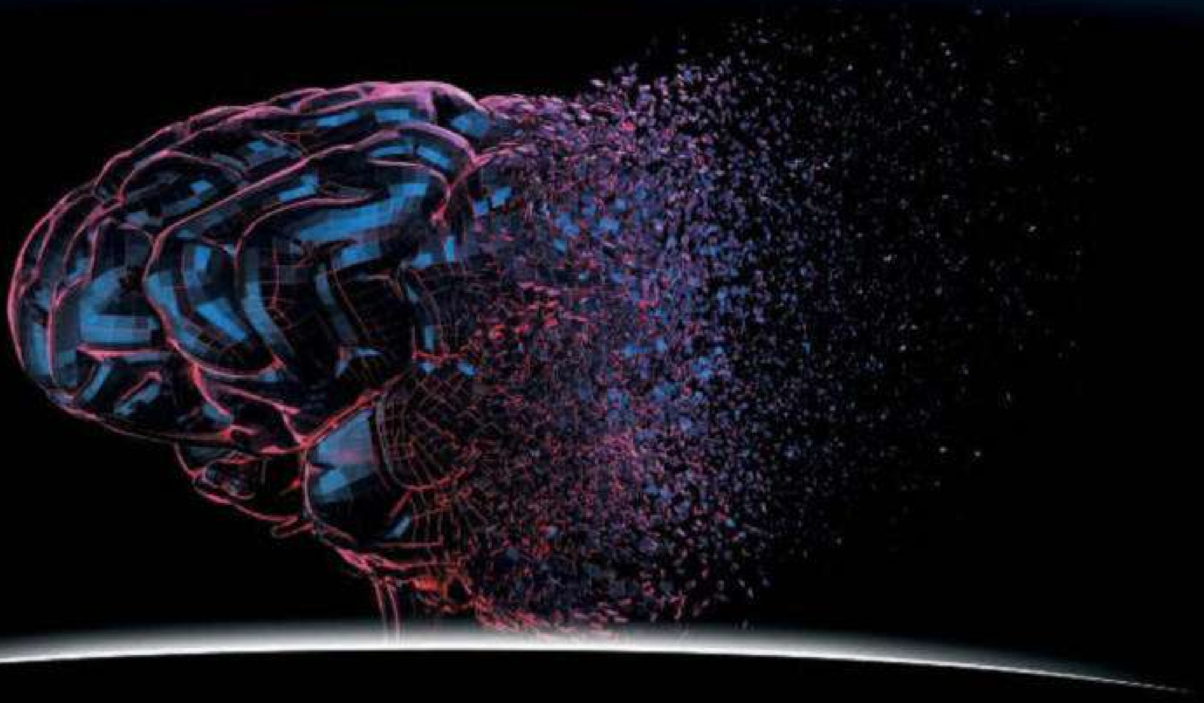

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# Murder on the moon

No one is better qualified to write a space thriller than Chris Hadfield, who has been there and lived to tell the tale, says **Jacob Aron**

**Book**
**The Apollo Murders**
**Chris Hadfield**
**Quercus**

I FOLLOW space flight pretty closely, and yet I couldn't tell you the names of the people currently aboard the International Space Station (ISS) without looking it up.

We weren't always this blasé about human space flight. In the early days of crewed missions, NASA's Mercury Seven astronauts were magazine cover stars and celebrities. In the 21st century, though, most astronauts are completely anonymous.

Chris Hadfield, the Canadian former commander of the ISS, is a rare exception. He first flew to space in 1995, riding on NASA's space shuttle to visit the Russian space station Mir. He came to public prominence much later, in 2013, during his third and final mission to orbit, when he used social media including Twitter and YouTube to swap messages with the likes of William Shatner and talk about life onboard the station.

All of this culminated with Hadfield releasing a cover of David Bowie's *Space Oddity*, recorded in microgravity. The video has since been viewed more than 50 million times, and is still as awe-inspiring as ever. While on the ISS, Hadfield made space seem exciting and relevant to the average person in a way that it hadn't been for many years. "Space flight isn't just about doing experiments, it's about an extension of human culture," he told me when we spoke following his return to Earth.

Since retiring from the Canadian Space Agency, Hadfield has written a number of non-fiction books, including his autobiography, *An Astronaut's Guide to Life on Earth*. Now, he has turned his hand to thrillers with *The Apollo Murders*, an alt-history set during the cold war that seemingly draws on his own space flight experiences and takes them to dramatic extremes.

The story unfolds in an alternative version of 1973, when a new kind of space race quickly gets ugly as both the USSR and the US are hoping to exploit an unusual find on the surface of the moon. Hadfield's version of 1973 has two key differences from our own. First, the Apollo 18 moon mission was redesignated to be a military operation run by the US Air Force, rather than being cancelled along with Apollo 19 and 20 following the failure of Apollo 13, as happened in reality.

Second, the Soviet Union's first attempt at launching an Almaz military space station was successful. The real version burned up in Earth's atmosphere after failing to reach a stable orbit, though a second attempt succeeded in 1974.

These two historical tweaks set the stage for the first military encounter in space – an event that thankfully has never happened in the real world. Old rivalries between the nations play out alongside personal grudges and a rising uncertainty about who to trust. The fact that back-up is almost 400,000 kilometres away only adds to the tension. It also allows Hadfield to unleash his inner Tom Clancy to great effect.

> "The story is improbable but not implausible. Hadfield only includes events that could have actually happened"

As someone who has actually been to space, Hadfield makes his techno-thiller jargon read true, whether it is the details of managing air pressure changes during a rocket launch or the blow-by-blow mechanics of hand-to-hand combat in microgravity.

Overall, the story comes across as improbable but not implausible. Hadfield is careful to only include events that could have actually happened. In this respect, there are echoes of the excellent Apple TV+ series *For All Mankind*, which also deals with an alt-history space conflict. While reading, I did wonder if Hadfield had been watching the series and taking notes – the book was written during lockdown in the covid-19 pandemic, so perhaps he had time on his hands.

Either way, I wouldn't be surprised to see *The Apollo Murders* get its own turn on the screen, because it seems ripe for adaptation as a film or TV series.

If I have one quibble, it is with the way that Hadfield has written some of the dialogue between Soviet characters. Scenes with Russian speakers that take place in the USSR are written in plain English, but when they encounter people from the US, the writing switches to transliterated Cyrillic, which is then repeated in English, to grating effect.

Still, it is a minor point for what is otherwise an accomplished story from a first-time novelist. Hadfield leaves the door open for potential sequels in this universe, and I am keen to see what he does next. ▮

FABIO FORMAGGIO/EYEEM/GETTY IMAGES

**Home feels a long way away when you don't know who to trust**

# Killing with blandness

Our predictable diets are playing havoc with the health of our bodies, our culture and the planet, finds **Gege Li**

**Book**

**Eating to Extinction**

**Dan Saladino**

Jonathan Cape

**OUR diets are more homogenous than at any other point in human history, says food journalist Dan Saladino. Particularly in the West, a revolution in farming methods since the second world war has led us to a point where much of what we eat comes from just a few established varieties of crops and animals, controlled by a handful of companies.**

**This has undoubtedly had many benefits for humanity, making food supplies more predictable, cheaper and more accessible, and helping to curb malnutrition. Yet in his new book, *Eating to Extinction: The world's rarest foods and why we need to save them*, Saladino argues that it has also pushed thousands of little-known foods, many with beneficial characteristics or rich historical and cultural significance, to the brink of extinction.**

**"The human diet has undergone more change in the last 150 years (roughly six generations) than in the previous one million years (around 40,000 generations)," he writes. This is worrisome, because restricting ourselves to such a narrow range of varieties diminishes the genetic variation that might protect crops and livestock from disease.**

**It also narrows the diversity of our gut microbiome, which is vital for our health and well-being, and risks the loss of entire culinary traditions forever. As Saladino puts it, "where nature creates diversity, the food system crushes it".**

**Through a narrative that weaves science and history with stories spanning every corner of the globe, Saladino makes an urgent call to protect the world's rare foods. The alternative, he warns, is a future where we lose our grip on nature and the vital services it provides, perhaps permanently.**

The foraging of Hadza honey in Tanzania is under threat due to increasing demand for land

KATIEKK2/GETTY IMAGES

**The book is split into 10 parts, each focusing on a different category: wild foods (hunted or foraged); cereals; vegetables; meat; fish and seafood; fruit; cheese; alcohol; stimulants (tea and coffee) and sweet foods. In every chapter, Saladino highlights a few ingredients and traces their origins, meeting the people who are championing food biodiversity. Often, these individuals represent the last line of defence between a food and its extinction.**

**Saladino covers so much ground that it is hard to touch on even a fraction of the foods he explores. Just one example of a rare food with a remarkable story to tell is Hadza honey, foraged by some of the few remaining hunter-gatherer societies – the Hadza people of Tanzania.**

**Through a relationship forged over millennia, the Hadza have learned to work together with honeyguide birds so both can reap the rewards of the nutritious honey found high in baobab trees.**

**But this special dynamic is under threat: the rising demand for land for crops and livestock is spilling into Hadza territory, putting their livelihoods at risk and depleting the supply of honey and other wild foods on which they depend. Saladino makes the impact of these potential losses clear, often rounding off a chapter with a moving story that underscores how tragic it would be if these foods ceased to exist.**

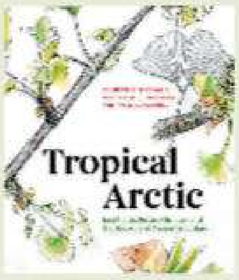
**Packed full of knowledge about a host of ingredients that you probably didn't even know existed, *Eating to Extinction* captures the urgency (and cost) of heading towards a future that is less nutritionally diverse.**

**"We cannot afford to carry on growing crops and producing food in ways that are so violently in conflict with nature; we can't continue to beat the planet into submission, to control, dominate and all too often destroy ecosystems," Saladino concludes. "The endangered foods in this book helped make us who we are; they could be foods that show us who we become."**

## Don't miss

**Visit**

**Cloud Studies** at the Whitworth in Manchester, UK, explores how war, industry and vested interests shape, alter and even poison the air we breathe. This is the last chance to see it, because the exhibition ends on 17 October.



**Read**

**Tropical Arctic** by palaeobotanists Jennifer McElwain and Ian Glasspool and scientific illustrator Marlene Hill Donnelly travels back 205 million years to a time when Earth's temperatures soared and Greenland was green.

**Watch**

**Dopesick** dramatises Beth Macy's exposé of how a pharma company encouraged doctors to prescribe OxyContin to a country already awash with painkillers. The series features Michael Keaton and Rosario Dawson (pictured).

CLOUD STUDIES COURTESY OF FORENSIC ARCHITECTURE; DOPESICK/HULU

**The film column**

# Oh, power of Scotland

A fresh look at Scottish industrial history demonstrates the complex challenges of balancing reasonable human aspirations with environmental protection, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram @simon_ings

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**Scotland's industrial past had repercussions for people and the climate**

**Film**

**Living Proof: A climate story**

**Emily Munro**

**Online now**

MOST environmental documentaries concentrate on the environment. Most films about climate change focus on people tackling the crisis. *Living Proof*, assembled and edited by Emily Munro, a curator of the moving image at the National Library of Scotland, is different.

It is a film about working people and their employers, about people whose day-to-day actions have contributed to Scotland's industrialisation, its export of materials and methods (particularly in the field of offshore oil and gas) and the associated environmental impact.

Collated from an array of public information films and promotional videos from the 1940s onwards, and set to a contemporary soundtrack, *Living Proof* is an archival history of what Scotland has told itself about itself. It also explores the local and global repercussions of those stories, ambitions and visions.

Munro is in thrall to the changing Scottish industrial landscape, from its herring fisheries to its dams, from its slums and derelict mine-heads to the high modernism of its motorways and strip malls.

*Living Proof* is also – and this is more important – a film that respects its subjects' changing aspirations. It tells the story of a nation that is trying to do right by its people.

> **"Much harm has been done to the planet in the name of doing what is best for the people"**

It will come as no surprise, as Glasgow prepares to host the COP26 global climate conference, to hear that the consequences of those efforts haven't been uniformly good. Powered by offshore oil and gas, and a redundancy-haunted grave for a dozen heavy industries, from coal mining and shipbuilding to steel manufacture, Scotland has a somewhat chequered environmental history.

As Munro's film shows, however, the environment has always been a central plank of arguments both for and against industrial development in Scotland. The idea that people in Scotland (and elsewhere) have only now considered the environment is nonsense.

Only towards the end of Munro's film do we meet protesters of any kind, deploring the construction in 1980 of a nuclear power plant at Torness, about 50 kilometres east of Edinburgh. Munro is less interested in the protest itself than in one impassioned speech that completes the argument begun in the first reel (via a public information film from the mid-1940s): that much harm has been done to the planet in the name of what is best for the people who depend on it, both as a home and a source of income.

This, indeed, is where we began: with a vision of a nation that, if it cannot support its own people, will go to rack and ruin, with (to quote that 1943 information film) "only the old people and a few children left in the glen".

*Living Proof* critiques an economic system that, whatever its promises, cannot help but denude the planet of its resources, often at the expense of its people. It is all the more powerful for being articulated through real things: schools and pharmaceuticals, earth movers and oil rigs, washing machines and gas boilers.

Reasonable aspirations have done unreasonable harm to the planet. That is the real crisis elucidated by *Living Proof*. It is a point too easily lost in all the shouting. And it has rarely been made so well. ▮

## Simon also recommends...

**Film**

**Bodysong**

**Simon Pummell**

*This BAFTA award-winning documentary about the human condition is woven from a dizzying array of archive resources.*

**Book**

**Growth**

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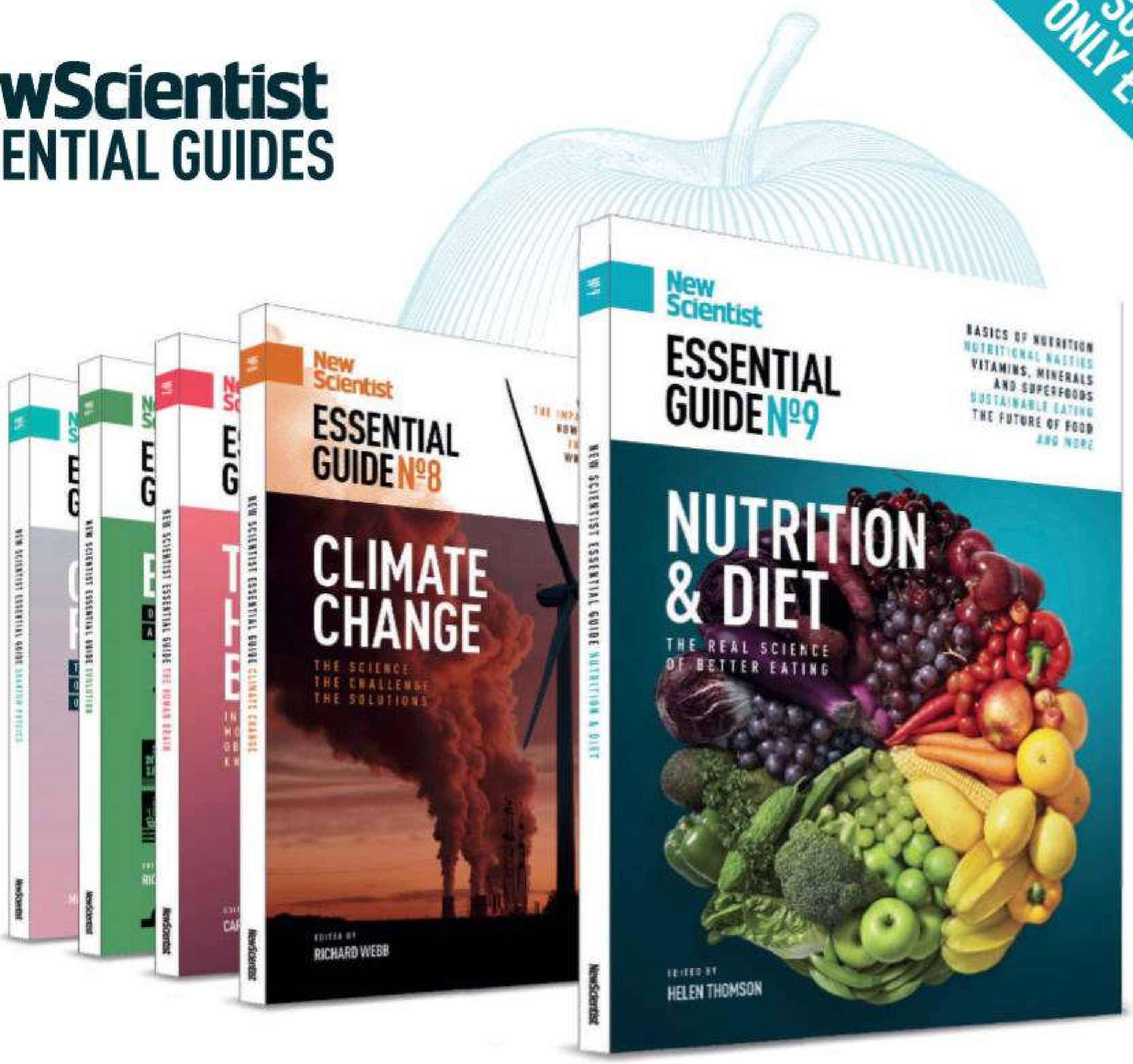

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# How do we build a sustainable future?

More than 1000 people joined *New Scientist* and a host of leading speakers to discuss the challenges we face to create a sustainable world. **Gege Li** was there

WE ARE living amid a global climate crisis, the greatest existential threat of our age. With a recent report by the Intergovernmental Panel on Climate Change (IPCC) concluding that we will reach 1.5°C of warming within the next 20 years, just what will it take to secure a sustainable future for both ourselves and the planet?

*New Scientist*'s virtual event on 25 September sought to address this pressing question with a packed day of talks from scientists and experts at the forefront of the effort to tackle global warming, including Christiana Figueres, an internationally recognised leader in climate negotiations and policy.

Almost 1400 people from 72 countries tuned in on the day. The audience had a rich choice of discussions across three main stages, covering a diverse range of topics. These included how to slash carbon emissions from ships and buildings, conserving vital carbon stores such as seagrasses and the climate impacts of the food on our plates.

The event also featured more intimate virtual spaces in which the audience could get a flavour of the ways that archaeology is teaching us lessons from the past that can inform present-day conservation, as well as a chance to experience innovations in sustainable food production and consumption.

This year marks an important moment for the future of our planet. Along with the publication of the IPCC report, the next worldwide summit on climate change – COP26 – is due to take place in Glasgow, UK, from the end of this month, with the aim of making key decisions that have the potential to change our climate future.

Ahead of this important event, on the main stage, our audience was treated to an absorbing Q&A session with Figueres and *New Scientist* reporter Adam Vaughan, who delved into what needs to happen to make COP26 a success.

Figueres highlighted the tougher language

**The UK Atomic Energy Authority's Nicholas Walkden joined Emily Bates in the studio**

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**Christiana Figueres spoke with *New Scientist*'s Adam Vaughan about her hopes for COP26**

adopted by scientists and governments in the IPCC report as a promising sign that we are finally moving away from cautious and restrained conversations about climate change, and instead directly accepting how critical our situation has become.

"We are conducting a completely unprecedented experiment with the only home that we know," she said. That experiment has already come at a high cost, with irreversible changes spurred by a warming planet, such as extreme weather events, becoming the norm across the world.

"We're never going to completely solve climate change. We are now in a state of the planet, and a state of human history, in which we will have to deal with a permanently changed atmosphere and global environment," said Figueres.

Another crucial ambition for the summit will be for all countries to commit to a 50 per cent cut in global emissions by 2030, Figueres said – the only way to keep warming within the 1.5°C threshold. She urged higher-income nations to make good on their promise of fulfilling the already delayed $100 billion funding pledge to support lower-income countries in cutting their emissions and adapting to a warming planet.

Despite these challenges, "we don't start from zero", said Figueres. Pointing to the success of the Clean Development Mechanism that paved the way for emission-reducing projects in lower-income countries, "let no one say we don't know how to do it because, actually, we do", she said.

More positive climate messages came from the next main stage event, when journalist and author Tom Heap shared with the audience his list of 39 ways to save the planet, which is also the subject of his podcast and forthcoming book.

Of the many pioneering ways in which people are combating climate change that Heap talked about, one of the most ingenious is biochar, a form of charcoal that is good at locking up carbon and can boost soil fertility in farming. It could provide a simple way of sequestering carbon dioxide by producing it from trees that absorb this greenhouse gas from the atmosphere. "You could take some of the waste wood out of [overgrown or burned down] forests, turn it into biochar, use it for farming, and you have captured and stored half of the carbon from that tree," said Heap.

He also shone the spotlight on seagrasses as a star contender for carbon storage thanks to their fast growth and ability to slow currents flowing over them, thereby trapping carbon-based material. However, seagrasses are in decline – the UK alone has seen 90 per cent of its seagrass meadows disappear. Restoration projects under way in many parts of the world are crucial to help not only curb some of the effects of climate change, but also to preserve these important marine plants.

Their preservation is especially crucial when considering the lifeline seagrasses provide for marine ecosystems, for example by fostering biodiversity, said Benjamin Jones, founder of conservation organisation Project Seagrass, on the People and Planet stage. "Our survival as a species depends on how we tackle climate change and biodiversity loss, and seagrass is really vital in securing that sustainable future," he said.

> **"We are conducting a completely unprecedented experiment with the only home that we know"**

Also on this stage, Sarah Bridle at the University of York, UK, presented an eye-opening talk on the environmental impact of different foods and how we can all make more climate-conscious dietary choices. A quarter of climate change can be attributed to food – a figure that is on the rise – and it will take both a shift in thinking and a transformation in the way we produce and market food to steer us out of this trajectory, said Bridle.

Meanwhile, on the Path to Net Zero stage, Catalina Spataru from the University College London Energy Institute spoke about net-zero carbon buildings as another way of achieving both the 1.5°C target set out in the Paris Agreement and a longer-term vision for a greener future.

Thanks to all the speakers and guests, the day gave an invaluable insight into the research that is underpinning progress towards combating climate change. It brought together promising scientific and technological solutions, highlighted areas that we must focus on and underscored the urgency of protecting our planet as we work towards a more sustainable world. ■

Gege Li is a freelance writer based in London

PABLO HURTADO DE MENDOZA

# Supersized AI

Gigantic neural networks write with remarkable fluency. Can scaling them up lead us to artificial general intelligence, asks **Mordechai Rorvig**

WHEN the artificial intelligence GPT-3 was released last year, it gave a good impression of having mastered human language, generating fluent streams of text on command. As the world gawped, seasoned observers pointed out its many mistakes and simplistic architecture. It is just a mindless machine, they insisted. Except that there are reasons to believe that AIs like GPT-3 may soon develop human-level language abilities, reasoning, and other hallmarks of what we think of as intelligence.

The success of GPT-3 has been put down to one thing: it was bigger than any AI of its type, meaning, roughly speaking, that it boasted many more artificial neurons. No one had expected that this shift in scale would make such a difference. But as AIs grow ever larger, they are not only proving themselves the match of humans at all manner of tasks, they are also demonstrating the ability to take on challenges they have never seen.

As a result, some in the field are beginning to think the inexorable drive to greater scales will lead to AIs with abilities comparable with those of humans. Samuel Bowman at New York University is among them. "Scaling up current methods significantly, especially after a decade or two of compute improvements, seems likely to make human-level language behaviour easy to attain," he says.

That would be huge if true. Few experts thought machine intelligence would arrive as a mere exercise in engineering. Of course, many still doubt that it will. Time will tell. In the meantime, Bowman and others are scrambling to assess what is really going on when superscale AIs seem to do human-like things.

Bowman is one of the world's foremost experts when it comes to evaluating language AIs. When he started his doctoral studies in 2011, artificial "neural networks" were just beginning to take over the field. Inspired by the real neural networks in the brain, they consist of interlinked processing units, or artificial neurons, which allow for programs that can learn. For a long time, it was unclear that computers would ever be able to do such a thing, says Ilya Sutskever, chief scientist of OpenAI, the San Francisco-based company that built GPT-3. "When I was studying computer science as an undergrad… it seemed downright impossible. And now we are just used to it," he says.

Unlike ordinary software, researchers don't give neural networks instructions. Rather, they are designed to be trained on a task until they learn to perform it well. Given a large set of images of animals, say, with a human annotation for each one, such as "dog" or "cat", a neural net can be trained to predict the correct label for an image it hasn't seen before. Each time it gets a label wrong, there is a systematic way for it to be told, so that, given enough examples, the network gets better at recognising the animals.

But these neural networks, also known as "models", aren't limited to identifying cats and dogs. In 1990, Jeffrey Elman, then at the University of California, San Diego, figured out a way to train a neural network to process language. He found that he could delete a word from a sentence and train a network to predict the missing word. Elman's model could do little more than tell the difference between nouns and verbs. What made it so beautiful was that it required no painstaking human annotations. He could create training data by simply deleting random words.

Eventually, researchers realised it was straightforward to retrain a model to tackle more specific problems. These include language translation, answering questions and sentiment analysis, where models gauge whether a human movie review is positive or negative, for example. ›

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By the time Bowman finished his PhD in 2016, language models had mastered many of the more routine tasks. No one was claiming that these models had anything remotely resembling intelligence: analysing sentiment might be as simple as cherry-picking words like "great" or "I loved it" from a review. But language models were getting better at harder tasks, too, almost as quickly as Bowman could come up with them.

The trick was to train models on more and more data – and in order to process vast swathes of text from the internet and other sources, the models had to be bigger. The field of AI was building neural networks in new ways as well, creating novel arrangements of neurons with different wirings. In 2017, Google researchers created a neural architecture called the "transformer" that proved especially scaleable. In search of ever better performance, researchers upgraded transformer-based models from hundreds of millions of parameters, each crudely analogous to a connection between neurons, to hundreds of billions – in just a few years (see "Going large," page 39).

> **"Language AIs show that scale alone can unlock surprising new abilities"**

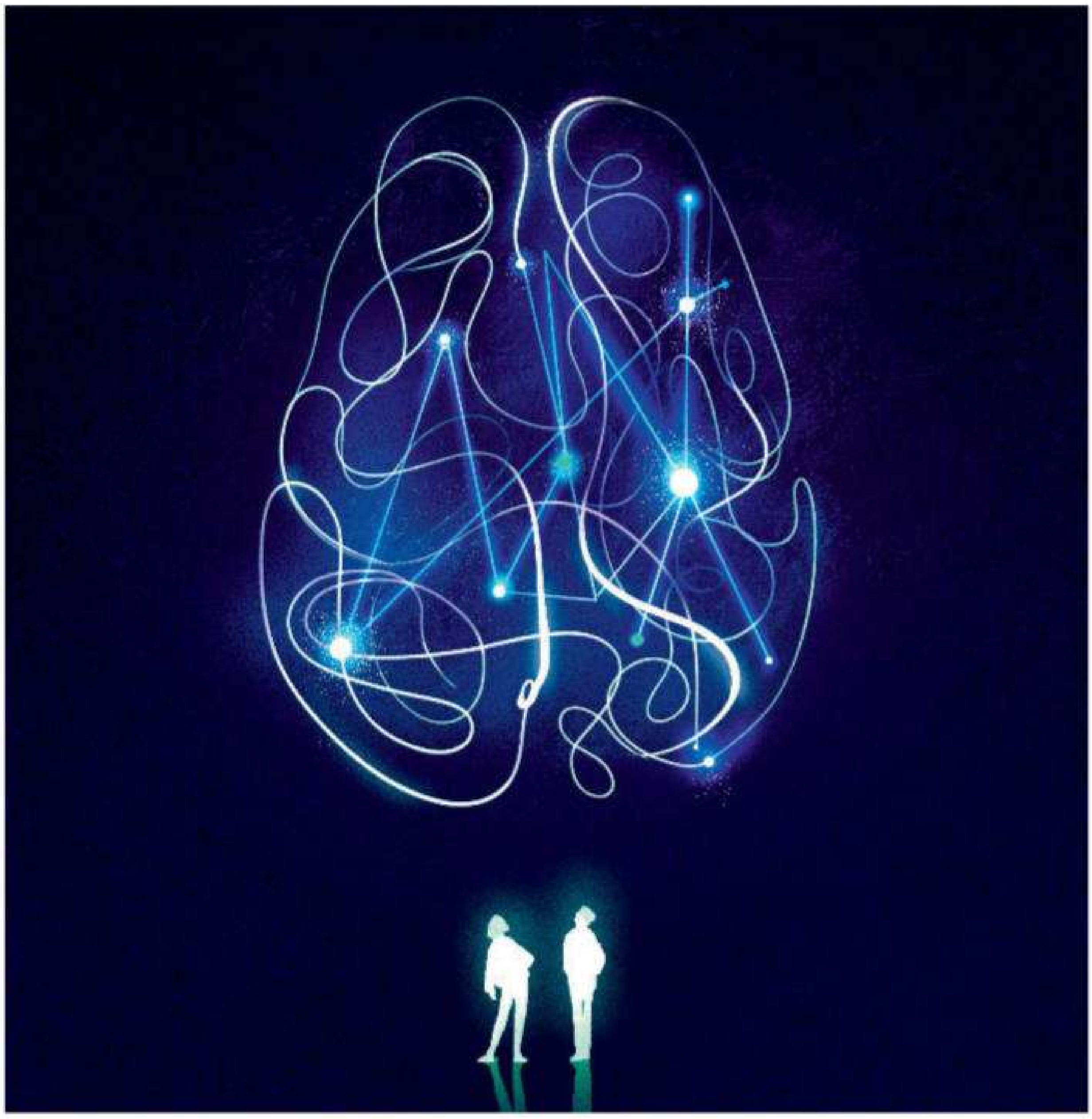
## Artificial reasoning

This strategy has paid off. The scaled transformer model has done things "orders of magnitude off my expectations about what would be possible with natural language", says Alexander Rush at Cornell University in New York and AI company Hugging Face. By late 2020, a transformer-derived architecture called BERT had overcome some genuinely difficult challenges. One of them involved general reading comprehension. Another tested abilities related to common sense reasoning. The models were asked to analyse sentences such as "The suitcase won't fit into the trunk of a car, because it is too big", and determine whether "it" refers to the suitcase or the trunk. The correct answer is the suitcase, of course. Solving this task requires a certain depth of understanding, says Bowman. And the models solved it at human-level, meaning they literally performed as well as humans did.

In the past few years, progress has come blindingly fast. And while architectural innovations like the transformer have been significant, most of this progress can be attributed to scale. "The very clear trend has been that most of the tests we are able to come up with get solved once you add like one more order of magnitude of scale," says Bowman.

Nowhere is this relationship between scale and smarts clearer than in the case of GPT-3, which arrived in May 2020. Boasting 175 billion parameters, GPT-3 was merely a scaled-up version of GPT-2, released in February 2019 with 1.5 billion parameters. Yet it demonstrated a vast leap from GPT-2 in its linguistic abilities, moving from struggling to write coherent paragraphs to producing 2000-word essays that can pass for human-level. "It's a phenomenon, really, the kind of language that it can produce," says Yejin Choi at the University of Washington and the Allen Institute for AI, both in Seattle.

True, it is still easy to catch out large language models. If you ask GPT-3 how many eyes a foot has, it might tell you two. And there



PABLO HURTADO DE MENDOZA

are still plenty of abilities that models like GPT-3 don't have, such as understanding cause and effect: figuring out, say, which of the phrases "it started raining" and "the driver turned the wiper on" should come first.

Even so, analysis of the gains already made suggests such flaws won't be insurmountable. Indeed, in 2020, OpenAI researchers found that the benefits of scale are predictable. They follow a clear-cut law: for every increase in the size of a GPT-style model, it can predict a missing word a little bit better, which translates into improved performance on all kinds of language tasks. This tendency has been demonstrated for models whose neural networks range from the size of a roundworm's brain to that of a rabbit. "It doesn't prove that they'll get better forever," says Jared Kaplan at Johns Hopkins University in Maryland, and formerly of OpenAI. "[But] my guess is it's probably going to continue for a while longer."

Moreover, new capabilities can appear from nowhere. For example, scaled-down versions of GPT-3 showed little ability at arithmetic – hardly surprising, given that they are only trained to predict the next word. But arithmetic abilities somehow appeared in the full-sized version. "Scale alone can unlock surprising new capabilities," says Jascha Sohl-Dickstein at AI research group Google Brain.

At a recent workshop, Sohl-Dickstein predicted that at the rate that models have improved on various language tasks, all such tasks might be solved when models reach the investment level of the Large Hadron Collider, the multinational physics experiment near Geneva in Switzerland – $10 billion to $100 billion, a large but far from unmanageable sum.

Solving every imaginable language task wouldn't necessarily mean a model was intelligent. Language behaviours are just a subset of what humans do. Nevertheless, recreating these abilities in a machine would be a huge deal, because it would seem to be a giant step towards achieving an artificial general intelligence, an AI that can do anything humans do, including self-improvement. Even Rush, who is deeply sceptical about the possibility of machine intelligence, thinks that scaling has now shifted the burden of proof onto those who proclaim that the hardest language problems will remain impossible. "People developing these models have done

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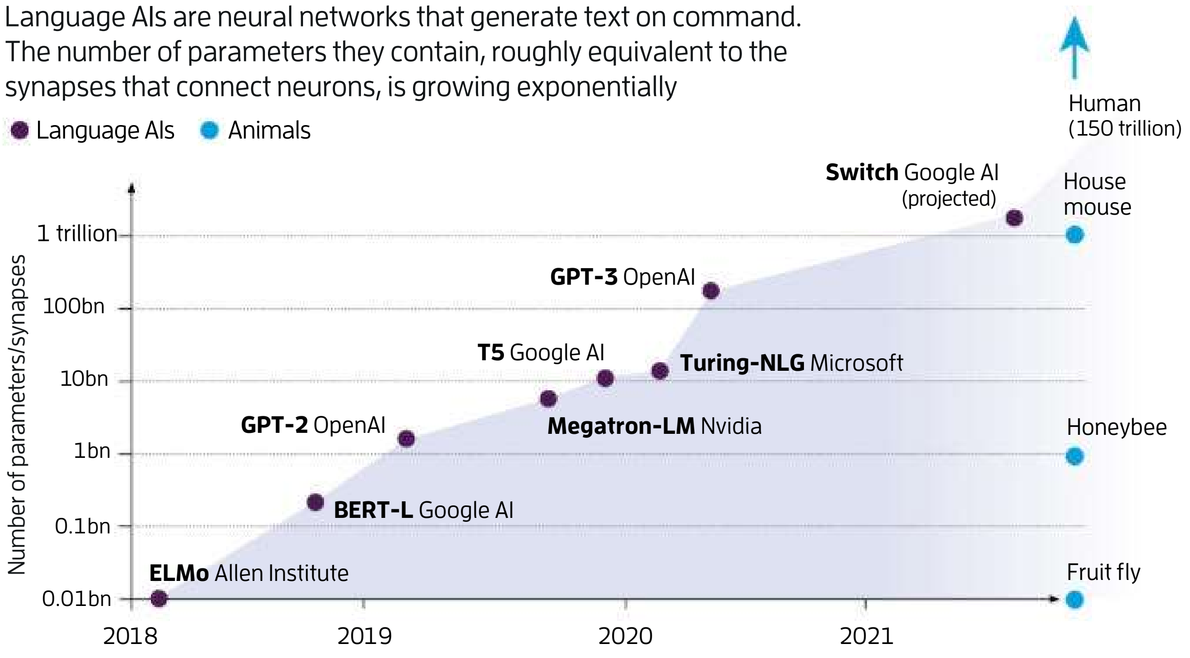
## Going large

Language AIs are neural networks that generate text on command. The number of parameters they contain, roughly equivalent to the synapses that connect neurons, is growing exponentially



SOURCE: arxiv.org/pdf/1910.01108.pdf

## Do AIs work like real brains?

**In the past few years, neural networks, the platforms underlying many of the most sophisticated AIs, have been scaled up exponentially. Striving for ever more parameters, roughly analogous to the connections between neurons in a real brain, is now standard practice (see main story). But what made people think simply supersizing the number of parameters would make dumb software smarter?**

**Ilya Sutskever is chief scientist at San Francisco-based OpenAI, which invested millions of dollars to make GPT-3, a language AI released in 2020 with a whopping 175 billion parameters. He was inspired to scale by the biological brain. Certainly, if you imagine that artificial neural networks are the same as the real thing, then scaling makes perfect sense. "The brain of a little insect is not going to be very smart, no matter how much you teach it," says Sutskever.**

**Artificial neural networks aren't the real thing, of course. For most of their history, they have been thought of as only poor approximations. But in recent years, we have begun to discover some intriguing similarities in the way the two work.**

**It is now possible to compare language AIs with the brain in various ways, for example. You can look at their timing, seeing how long it takes to analyse the next word. You can also look at their insides to see whether a neural network has the same pattern of activations – equivalent to neuron firings – as does a brain, whose activity can be traced with MRI signals. Remarkably, for some regions of the brain, language AIs seem to follow almost the same pattern. "There is a significant similarity between the two," says Mariya Toneva at Princeton University.**

**More recently, Martin Schrimpf at Massachusetts Institute of Technology and his colleagues showed that scaling neural networks made their patterns even more brain-like. "There is a relatively smooth improvement when scaling up," says Schrimpf. So, although it has long seemed natural to assume that artificial neural networks don't work anything like real brains, it seems we might have to think again.**

everything they can to show that scaling defeats these problems," says Rush.

This hasn't gone unnoticed. Soon after GPT-3's release, an independent researcher named Gwern Branwen called attention to the astonishing achievements of scale in a blog post that was widely read by AI researchers. "If only one could go back 10 years, or even 5, to watch every AI researchers' head explode," Branwen wrote.

But surprisingly, few others have been shouting from the rooftops. To some extent, this can be attributed to a certain cautiousness that is baked into the community. "There's lots of examples in our field specifically of overpromising and under-delivering," says Colin Raffel at the University of North Carolina and Hugging Face.

The other thing, of course, is that not everyone is convinced about the powers of scale. Some, like Raffel, think that scaling can only take us so far. To some extent, models can be thought of as memorisation engines, he says. As they get bigger, they memorise more. But for a model to memorise everything, or even as much as Google Search, say, its size would need to be unthinkably large. "That probably is far beyond the limits of what we can currently train," says Raffel.

The counterargument is that if scaled-up models can indeed do human-like reasoning, then they don't need to memorise everything – humans don't, after all. At present, there is no doubt that human-level reasoning is beyond current language AIs. The question is, will they attain it with scale?

Choi thinks not. She argues that scale alone will not be sufficient to endow software with human-like reasoning. For her, the fact that current models merely predict the next word poses a deep limitation to what they can learn. "If I ask [a model] 'how many sides does a ball have?', it might say four, because it's trying to get lucky with predicting which word is likely to come next," says Choi. Such a crude architecture can never acquire fully human-like reasoning, she says.

> **"We need better ways to assess AIs, and how they compare with humans"**

For others, there are now reasons to disagree. It has often been argued that when models succeed at reasoning, it is only because they have memorised patterns from countless examples. "There's always this theory that you just learned the trick of the test," says Bowman. But GPT-3 doesn't even need test-taking examples. If you explain a made-up concept called a "Burringo" and tell it that it is a very fast car, GPT-3 will immediately begin to reason about the word well, speaking about keeping a Burringo inside a garage.

The ability to learn new things from scratch is one of many signals that models can reason like humans do, says Bowman. "It's ruling out that your abilities are specific to the test and don't apply in the real world," he says.

It will take time to see just how far scaling can take artificial intelligence. Plenty of people believe in the necessity of taking different approaches to making further progress. Choi is working on augmenting scaled architectures, for example. She is seeking to give them an ability to learn interactively, asking questions and engaging in the way that humans do. Kaplan, for his part, wants models to have the ability to train themselves on text that matters, rather than endless libraries of Reddit discussions or random Wikipedia articles.

But whichever way we might get to artificial general intelligence, if indeed it is even a realistic goal, what is already clear from scaling language models is that we need more sophisticated ways to assess the intelligence of AIs – and how they compare with our own. "There are so many reasons why a model could be succeeding or failing at a task, and some of them are consistent with being 'intelligent', so to speak, and some are not," says Pavlick.

We are only just beginning to develop the tools required to see if what language models are doing really resembles human abilities, she adds. But recent work has already produced some intriguing results. In one study, Pavlick looked at whether models learn systematic reasoning, something humans are known to do. In the sentence, "The dog that chases the cats runs fast," humans don't need to have seen the sentence before to know that "runs" is correct, instead of "run". They simply recognise that this is part of a general, systematic pattern. Pavlick has shown that, with some caveats, BERT-based models do similar, systematic reasoning. "It's not like you have a model that's kind of arbitrarily memorising and mapping inputs and outputs," she says. "It seems to have internal representations that are consistent with what we're looking for."

Scaling itself is now changing. Researchers have recently figured out how to devise models that can train themselves on images and videos, as well as words. This allows them to learn from vastly more data of a much richer nature, more like humans do. Soon, Google is due to show results from a trillion-parameter model, the biggest ever. Who knows what fresh revelations that will reveal? "I'm nervous and curious and excited," says Bowman. Kaplan says something similar: "We should be paying very close attention." ■

Mordechai Rorvig is a science writer based in Atlanta, Georgia

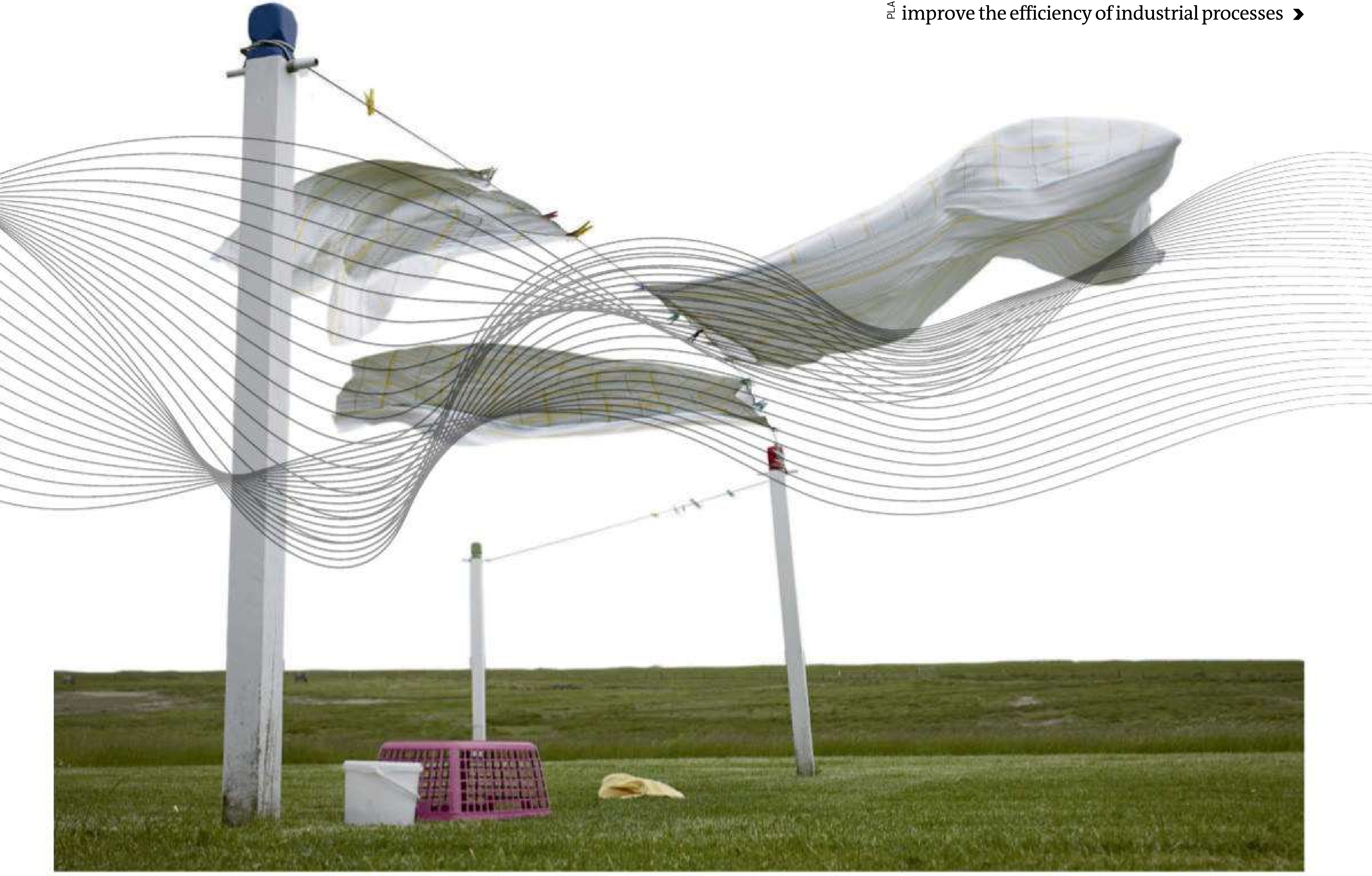
# Blowin' in the electric wind

Breezes conjured at the flick of a switch could power aircraft, make vehicles more efficient and smooth our path to green energy, says **Ben Skuse**

THE wind is nothing if not capricious. It can be a gentle breeze, making fallen leaves dance and clothes flutter on the washing line. Or it can blow a gale, tearing down trees and power cables and causing all manner of damage. But what if we could switch the wind on and off at the push of a button, or turn it up and down with a dial?

We're not talking about a mechanical desk fan here. There is, as it happens, such a thing as electric wind – airflow induced by electric fields, no moving parts required. We have known about the phenomenon for centuries, but it is only in the past few years that we have come to understand electric wind with the precision needed to control it.

Now the challenge is to put it to work. Engineers have already flown a simple aircraft pushed along by electric wind. We might use a gentler, finely tuned breeze to help improve the efficiency of industrial processes ›



PLAINPICTURE/ELEKTRONS 08

> **“Contraptions made of foil and wire will hover in mid-air, supported by the electric wind”**

like steel-making and to lubricate our transition to a greener energy system. Ultimately, we might even use it to protect ourselves against the destructive force of natural winds too.

Electric wind, sometimes called ionic wind, was discovered in 1709 by Francis Hauksbee the Elder, then the curator of instruments for the Royal Society of London. Hauksbee reported that he rubbed a glass tube to give it a static charge and, when he held it close to his cheek, he could feel a gentle force. Isaac Newton repeated the experiment and confirmed the finding. “The electric vapour,” he later wrote, “will sometimes push against the finger so as to be felt.”

Newton didn’t fully understand what was going on. By 1899, however, physicist Arthur Prince Chattock had mostly figured it out, leaving only a few loose ends (see “How the electric wind blows”, left). If you apply a high voltage to a pair of electrodes spaced apart, this strips electrons from molecules in the air and creates charged particles. These are then tugged towards the oppositely charged electrode. As they fly through the air, the charged particles collide with other molecules and impart some of their momentum to them, creating a wind-like flow.

School children have been using this effect for decades to build tiny “lifters” at science fairs. These are small contraptions made of foil and wire that are tethered to the ground but hover in mid-air, supported by electric wind. In fact, it was school science projects like these that inspired Steven Barrett at Massachusetts Institute of Technology to begin a quest to build a new kind of aircraft.

## How the electric wind blows

**Electric wind is generated when charged particles moving from one electrode to another hit molecules in the air and transfer some of their momentum, creating a breeze. But how exactly does this happen? There are so many molecules in the air that you would expect a few charged particles to get smothered and run out of steam before they get anywhere.**

**It was generally thought that the ions involved must take a ride on streamers, which are electric discharges that slice through the air like miniature lighting bolts. Streamers scythe a clear path through the air, making them the most favourable path between the electrodes – or so it was thought.**

**In 2018, Uroš Cvelbar at the Jožef Stefan Institute in Slovenia and his colleagues looked into the matter using a special kind of photography. They found that the streamers aren’t the rails that the electric wind runs on. Instead, they act more like a snowplough, clearing a path that the charged particles can then more easily whizz along to create a breeze. This seems to be how the electric wind manages to not fizzle out straight away. Cvelbar hopes the discovery will help him put this wind to work (see main story).**

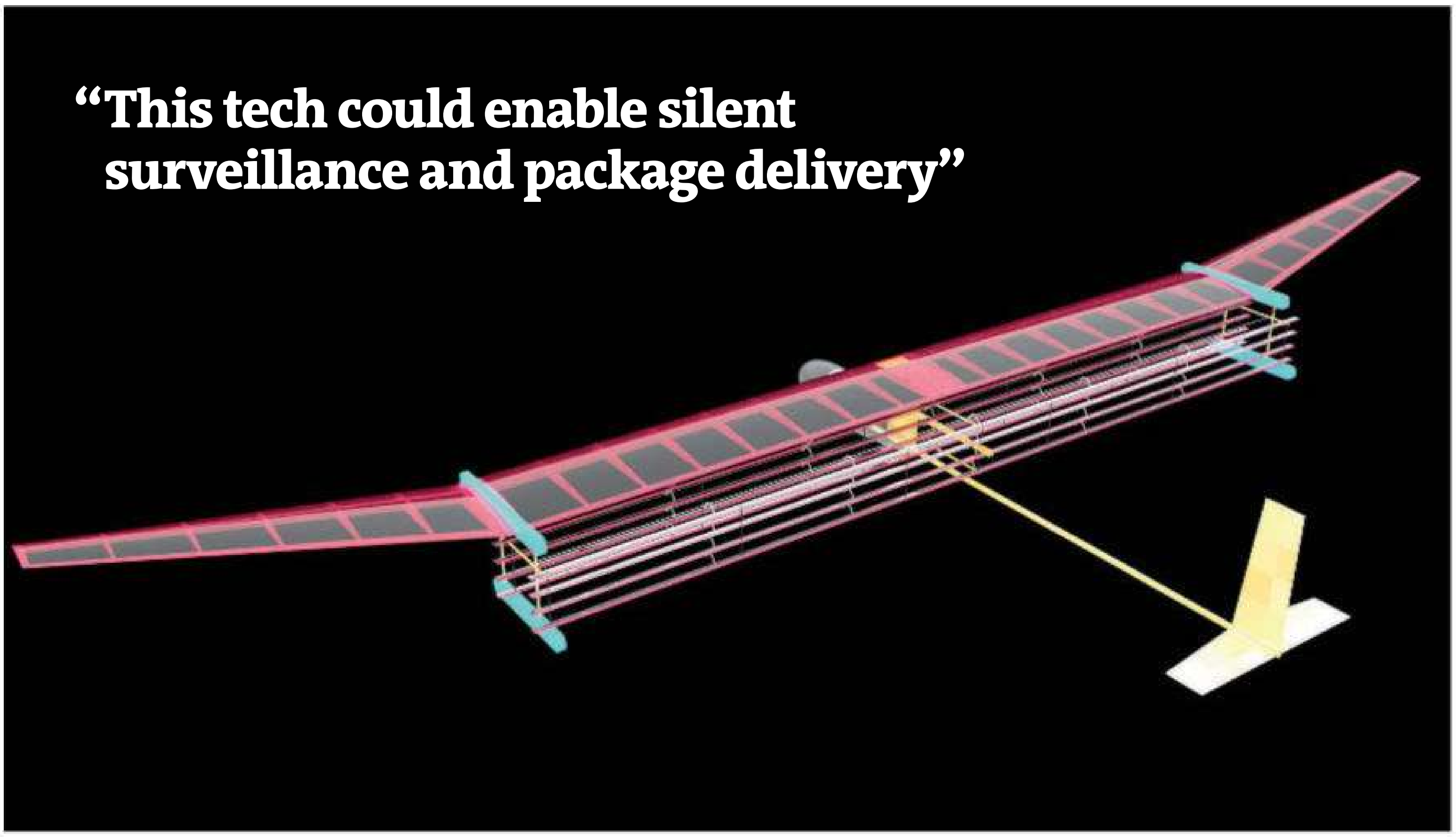
## Dream plane

Most planes are heavy, highly complex machines that guzzle fossil fuel. Barrett’s dream was to make a plane with no moving parts that moves through the air using the electric wind as thrust. It took him and his team nine years to unpick the physics. But in 2018, they flew a prototype they called EAD Airframe V2. It was a first-of-its-kind flight. It also was also rather primitive: the prototype had a wingspan of just 5 metres, weighed 2.5 kilograms and flew only 60 metres.

It remains to be seen whether it can be scaled up. One limitation is power – a larger, heavier plane would need the electric wind engine to generate much more thrust. Barrett has been working on this and says he is close to flight-testing a new prototype capable of carrying a small payload. “If the calculations are correct it should fly for something like 10 or 20 minutes instead of about 10 seconds,” he says. “It would have to be improved another order of magnitude beyond where it is now, but it could be the fundamental enabling technology for silent air-quality monitoring, surveillance or urban package delivery.”

As well as providing a driving force for vehicles, electric wind could help make them more efficient. Ramis Örlü at KTH Royal Institute of Technology in Stockholm, Sweden, says a large portion of a flat-nosed lorry’s fuel is wasted via wind resistance. Designed to cut through the air, lorries’ aerodynamics do a good job of dealing with front-on gusts but

“This tech could enable silent surveillance and package delivery”



**The EAD Airframe V2 has no moving parts and flies in almost total silence**

MIT ELECTRIC AIRCRAFT INITIATIVE

struggle more in side winds. Örlü and his colleagues think adding an electric breeze to the mix might help. Their solution involves sticking strips of tape judiciously around the lorry’s cab and using these as electric wind generators. Arranged in a smart way, these generators can create whirling vortices that force the air to flow over the cab with less resistance. Using a scale model, Örlü’s team showed that this can reduce drag by 20 per cent. “Even if you account for all the electricity to operate the sensors and actuators, it’s still a net gain,” he says.

One big problem ideas like this would probably face is public acceptance. Would you want to drive down a road surrounded by tens of thousands of volts of electricity? Even Örlü admits: “It doesn’t sound very safe.” However, he is working on embedding the strip generators safely within the lorry cab’s chassis.

High voltages are less of a worry in heavy industry, which is why electric wind might find its first uses there. We have known for some time that these induced breezes can be used to mould flames into desirable shapes and control the flow of oxygen so that the fire burns as efficiently as possible. Engineer Min Suk Cha at King Abdullah University of Science and Technology in Thuwal, Saudi Arabia, and his colleagues have been doing this for years. Their experiments have been slowly unpicking the details of how flames respond, with a view to making industrial burners – the sort used to create chemical reactions or melt metals – combust in a cleaner, brighter way.

Yet Cha has a higher ambition for electric wind. He thinks it could be key to a smooth transition to a sustainable world. One part of that shift might involve swapping natural gas and petrol for greener fuels such as hydrogen in the engines of cars, planes and other machines. Unfortunately, all these fuels burn in different ways and need their own special engine designs – you can’t just fill your car engine with hydrogen because the flame instabilities could be dangerous.

## Splashes and bubbles

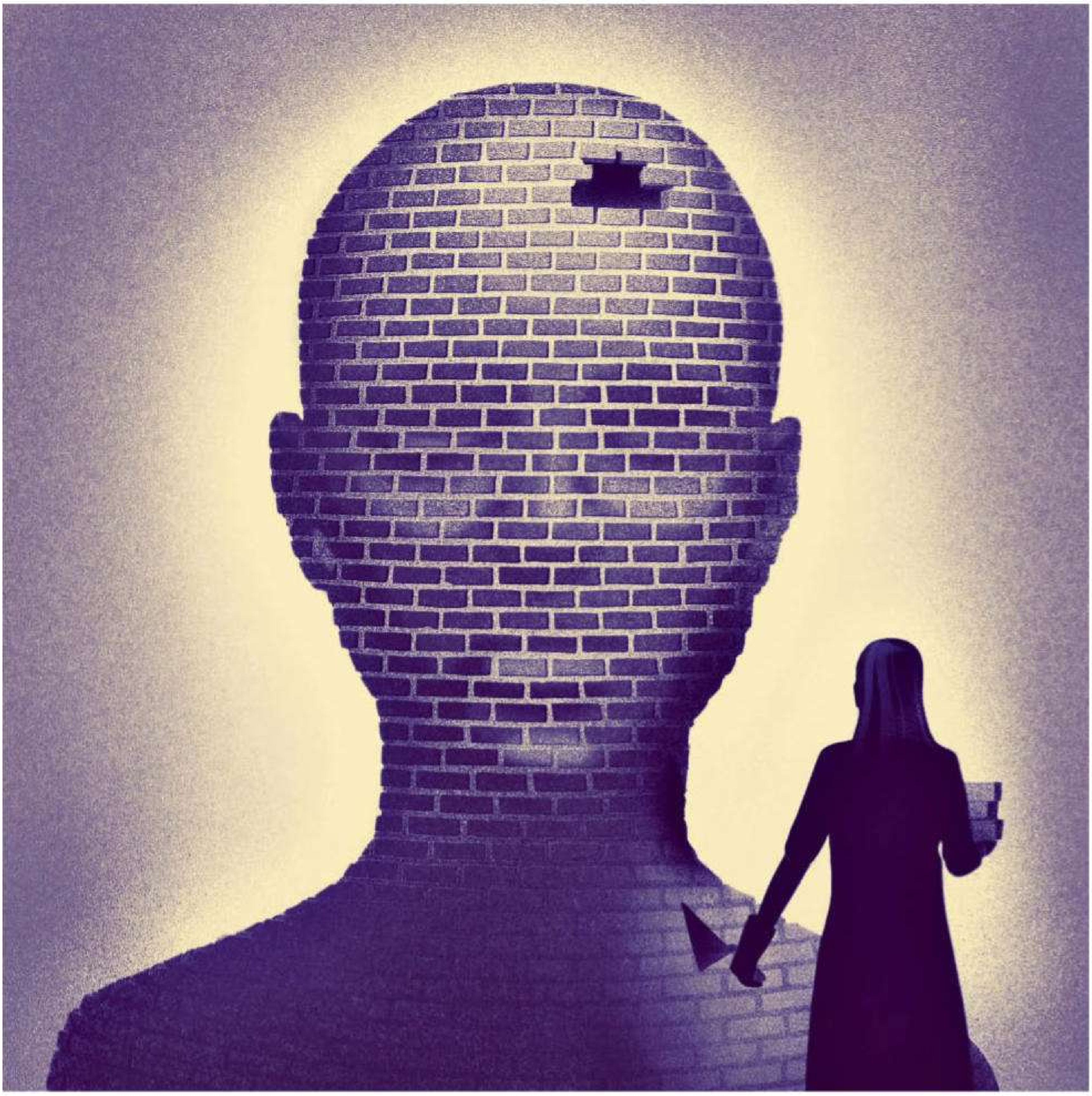
But perhaps there is a workaround. Cha thinks retrofitted electric wind generators on existing engines could be programmed to control flame instabilities arising from whatever fuel you used. He has yet to prove this will work, and according to combustion engineer Tim Lieuwen at the Georgia Institute of Technology in Atlanta, “there’s a real challenge in whether these technologies can scale up”. But if they can, they could help bridge the gap to a net-zero society.

Uroš Cvelbar at the Jožef Stefan Institute in Slovenia and his colleagues are also interested in green applications. They have recently wielded electric wind to blow onto water to create unnaturally large depressions in the liquid that didn’t splash, bubble or fall apart. This kind of trick could prove useful in steel-making, for instance, which involves blowing air over the top of molten iron. Removing surface instabilities during these processes would improve steel quality and reduce energy losses. Any improvement could be valuable, as steel manufacturing is one of the most difficult industrial processes to turn green.

Cvelbar is no stranger to the power of the real wind. Powerful gusts often arrive in winter on the Adriatic Sea near where he lives in Slovenia thanks to the bora, one of the wildest winds in the world. “All the rooftops in our region have to be loaded with stones so that the bora doesn’t blow them away,” he says.

The Maslenica bridge, which carries part of a major road in neighbouring Croatia, was closed 68 times in 2019 thanks to gusts exceeding 200 kilometres per hour, well above hurricane force. Cvelbar reckons electric wind generators fitted to the bridge could take the kick out of the bora. It would involve strategically placed electric wind generators that would look like high-tech chicken wire fences. “They would be activated at high winds, with force in the opposite direction to tame the wind,” he says. Getting the scheme working will require investment, no doubt. But Cvelbar is optimistic that one day we will be able to fight nature’s fury with the flick of a switch. ▮

Ben Skuse is a science writer based near Bristol, UK



DANIEL STOLLE

# The mysterious memory gap

Can memories resurface after decades in hiding, or is it a cruel trick by the brain, asks **Jessica Hamzelou**

ON A February night 10 years ago, John Zebedee murdered his father. As John later told police, he was awoken by 94-year-old Harry Zebedee, who had dementia. When John went to check on him, Harry made a gesture that triggered John's memory of childhood sexual abuse his father had inflicted. When the older man was found strangled to death, John confessed to the killing. He was later convicted of murder.

At the time of his arrest, John described in detail how his father had assaulted him when he was a child. But months later, John said his father hadn't abused him after all. "He wrote to me from prison," says psychologist Julia Shaw at University College London. He told Shaw that he had sought treatment for an alcohol use disorder and it was only then that the subject of abuse came up. "He says that… a therapist suggested to him that he must have been abused as a child," says Shaw.

The idea that memories can be repressed, only to suddenly re-emerge years later, was debunked in the 1990s, when memory researchers pointed out that the concept goes against everything we know about how memory works. They also noted that it is so easy to implant false memories that it is impossible to tell a recovered memory from an implanted one.

With that, the idea should have been consigned to history. Yet in recent years, it has become clear that the belief in memory repression has lingered among some therapists, the public and in the criminal justice systems of many countries. "It has not ended at all," says Henry Otgaar, a clinical and forensic psychologist at Maastricht University in the Netherlands. "It could be even worse."

Otgaar and others are warning that, in an era where historical cases of sexual abuse are increasingly being investigated, good science is more important than ever. Unless something changes, he believes, unsafe convictions based on bad science will wreck lives, while people with real, but patchy memories of abuse might not be believed. And people who believe they have uncovered repressed memories can experience significant distress, sometimes unnecessarily, as can their families.

The idea that memories can be repressed can be traced to Sigmund Freud, the founder of psychoanalysis. Freud believed that certain uncomfortable urges or painful experiences could be locked away from the conscious mind, to protect a person from further suffering. "The idea is that… this automatic defence mechanism kicks in," says Chris French, an emeritus professor of psychology at Goldsmiths, University of London. "It shoves the memory deep down into your non-conscious mind, and it's completely inaccessible."

Freud himself changed his mind about memory repression, but the idea gained ground all the same. Buried memories of trauma might explain why some people experience mental health conditions later in life, the idea goes, and the best way to treat › these conditions is by coaxing people to recall these traumas in order to process them.

This view was especially popular among therapists in the US during the 1980s and 1990s. It led to a spike in legal cases, in which adults described how, after seeking treatment for a mental health issue such as an eating disorder or depression, they discovered long-lost but vivid and detailed memories of childhood sexual abuse.

The release of a high-profile memoir in 1980, *Michelle Remembers*, was one driver of the trend. It was based on the account of a woman who, in therapy, retrieved memories of being abused by a satanic cult whose members included her mother. The account was later shown to contain multiple inaccuracies, but not before it had spawned panic in the US about the possibility of a hidden underground of satanic sexual abuse.

"IF THE BRAIN HAS A WAY TO LOCK AWAY MEMORIES, IT HASN'T BEEN FOUND YET"

At the time, Elizabeth Loftus, a psychologist at the University of California, Irvine, was researching the way that witness statements could be vulnerable to suggestion and distortion that could change the account of an event. She wondered if something similar could be happening in cases where memories appeared as if from nowhere. In the research that followed, she showed that not only could this happen, but that there was no way to explain repressed memories using our best understanding of how the brain works.

The idea of repressed memories relies on the assumption that our memory works as a filing system, maintaining crystal-clear records of events and storing them away for future retrieval. In fact, far from being a faithful record of events, our memories are malleable.

The formation of a long-term memory requires the strengthening of electrical connections between different parts of the brain, specifically the hippocampus and the cortex. Signals from various brain regions might be incorporated to add details to the memory, such as the smell of a person or the feel of a carpet in a room. Being reminded of one of these sensations – a taste or smell from childhood, for example – can bring back the others. Recalling – or "rehearsing" a memory strengthens the connections in the brain, making it easier to retrieve.

Once encoded, these memories are far from fixed, however. Every time we recall an event, we have the chance to alter the memory in some way. That reactivated memories are vulnerable to change is a feature that allows us to update the way we understand the world around us. But it also means that your memory of a past event is only as good as your most recent recollection of it.

This is partly why we forget things, and there is no doubt that we do forget things. First of all, some details of our experience, including those of truly horrible events, don't get committed to memory. Otgaar gives the example of someone being threatened at gunpoint: it is possible that the person may have focused on the gun and so can't remember the face of the perpetrator. "That's not a repressed memory," he says. The memory may have never formed in the first place.

It is also possible that traumas can be entirely forgotten over time, especially those that were experienced at a young age. We rapidly forget events when we are young, and don't tend to remember experiences from before the age of about 4. It isn't clear why this is the case, but some suggest that the brain isn't yet mature enough to create long-term memories.

Cara Laney Thede, a psychologist at the College of Idaho, also points out that, in general, old memories tend to be hazier. "Past events are more likely to be lost, unless they are rehearsed," she says. This can even be true for traumatic memories. When 129 women with documented experiences of childhood abuse were interviewed 17 years after the abuse was reported, more than a third didn't recall the original abuse, for example. Those that were younger at the time of abuse were the least likely to recall it. The same study also showed that those who were subjected to more force and those who were emotionally close to the perpetrator were more likely to forget the abuse. Other studies have found that deliberately not rehearsing memories can weaken them – suggesting that if a person deliberately chose not to recall an event, the memory of it would weaken over time.

"People can completely forget about [traumatic events]," says Chris Brewin at University College London. "Things can be forgotten, and we don't know why." Because there is often no way to be sure whether an event took place or not, recovered memories of trauma could be "genuine, false, or a mixture of the two", he wrote in a paper in *Perspectives on Psychological Science*.

For all that, however, most researchers don't believe that faded or forgotten memories can somehow be retrieved in detail years later, as if the repression lock has been suddenly removed. "There is no credible scientific support for that idea," says Loftus. Indeed, there is no known mechanism for storing away memories without being able to access them, says Larney Thede. If the brain has a way to lock away memories, it hasn't been found yet.

What muddies the waters further is that there is plenty of evidence that implanted memories can, over time, feel as real to the person experiencing them as something that actually happened.

We have known about implanted memories for a while now. In a seminal study, published in 1995, Loftus and her colleagues asked 24 adults about their childhood experiences. After speaking to the volunteers' parents, the team asked each volunteer about three real

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experiences and one that was entirely invented – getting lost in a shopping mall at the age of 5. Just over two-thirds of the real events were remembered. But seven of the 24 participants also remembered the made-up event and were able to describe what they thought had happened.

Since then, multiple studies have demonstrated the same phenomenon. More recent work has shown that people can easily be led to believe they have given someone a black eye or experienced a hot air balloon ride, for instance, when they haven't.

In one large online study, with more than 5000 participants, 50 per cent of people said they remembered news events that had been fabricated by the researchers. Even once they were told that some of the stories they had been shown were fake, a quarter of the participants said that they remembered the event, and couldn't recognise it as false.

False memories can be just as upsetting as memories of real events. People who claim to have been abducted by aliens are totally convinced by their memories of what happened, and when recalling the "memory" of the event they get just as stressed as people who have experienced documented trauma. To investigate this further, Richard McNally at Harvard University and his colleagues compared the physiological responses of people who were known to have experienced trauma, whether as a result of war or sexual abuse, and those of people who said they had been abducted by aliens. As the participants described their experiences, the researchers measured their heart rate, sweating and muscle tension. There was no observable difference between the two groups. More than half of those who believed they had been abducted by aliens showed signs of post-traumatic stress disorder.

This suggests that, without corroborating or exonerating evidence, it is impossible to tell if a memory is real or false, says Loftus. Lawrence Patihis, a forensic psychologist at the University of Portsmouth, UK, who used to believe that repressed memories exist, also points out that certain kinds of therapy, which encourage people to imagine scenarios or elaborate on remembered fragments, may cause false memories to take hold.

How can we distinguish implanted memories from real ones? One red flag is if someone says they have recalled an event that they had completely forgotten but are able to suddenly describe in striking detail, says Patihis. Research into memory suggests that memories fade over time, unless they are recalled regularly. "It would be impossible to

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recall abuse you had no idea about with detail 30 years later," he says. "To create perfect memories out of nothing just doesn't add up."

Another thing to look out for, says Patihis, is how these detailed accounts emerge. If a therapist believes that a patient has repressed memories, they may, sometimes inadvertently, encourage them to describe things that might not be true during therapy sessions.

"The therapist could use guided imagery, in which the patient is guided by the therapist to imagine what the abuse could have been, and expand that in their mind and add to the scene," says Patihis. "Week to week, that imagination turns into the belief that something happened."

The search for differences between true and false memories is an area of ongoing research, says Laney Thede, who says it forms a huge proportion of her work. "Child sexual abuse happens all the time, and it's terrible," she says. "But we need to develop techniques… to separate the true from the false memories." Some researchers have tried to compare real and false memories in a lab setting, exploring how people's recollections may differ between the two or looking for differences in brain activity when real and falsely remembered events are recalled. Today, there is still no way to distinguish a true memory from a false one.

Closing this gap is important, not only to prevent tragedies like the murder of Harry Zebedee and unsafe convictions, but also to make sure people who are truly guilty can't get away with their crimes. The arguments against memory repression shouldn't discredit the validity of claims of sexual trauma, says Brewin. Equally, there is a need to protect vulnerable people from the ordeal of working through potentially false traumatic memories.

This is particularly important because Loftus's work suggests that "recovering" memories of trauma doesn't improve a person's mental health and well-being. Quite the opposite. When Loftus looked at 30 randomly selected cases that had been approved for state compensation in Washington state, she found that people who had recovered memories generally felt worse

## Bad therapy

**When Jeanette Bartha was diagnosed with depression in her late 20s, she was referred to a therapist. He didn't use the term "repressed memory" but told her that the reason she was depressed was because she couldn't remember something that had happened to her. Remembering the traumatic experience would help her get better, he said.**

**She was hospitalised for what turned into an initial three-year stay, followed by multiple readmissions. While she was in hospital, Jeanette started believing that her uncle might have been abusive. Later, she began to describe satanic ritual abuse. "I'm not even sure how that got started, but I was hanging out with other people who had the same diagnosis," she says. "We would feed off each other constantly… soon enough I would start having the same memories, or something similar."**

**Far from healing her depression, these "memories" took a further toll on Jeanette's well-being. "You're told that you killed people, that you ate people, and it just starts making you think oh my god, I'm a monster," she says. "I got worse and worse and worse, and I don't know anybody who actually got better. I know five people who died – most by suicide."**

**After her release from hospital, while her therapist was away on holiday and out of contact, Jeanette began to fear that she was on the same path. She moved away from the area and took legal action against the therapist. She has since accepted a settlement. And although Jeanette has experienced post-traumatic stress disorder and chronic fatigue since her ordeal, her symptoms are improving. "I refuse to allow him to mess up my life," she says.**

**The fear of a secret satanic cult engaging in ritual child sexual abuse gripped the US in the 1980s**

SERGIO DELLE VEDOVE/GETTY IMAGES

FIORDALISO/GETTY IMAGES

**Some forms of therapy may inadvertently lead to false memories**

"FAMILIES HAVE BEEN TORN APART BY ACCUSATIONS OF ABUSE THAT WERE LATER RETRACTED"

after treatment, not better. In the study, published in 1996, 26 of the 30 individuals had first recalled childhood abuse during therapy. Three of the claimants said they had considered suicide before therapy, but 20 did after "remembering" abuse. Two had been hospitalised before "recalling" the abuse, while 11 were hospitalised afterwards, and one had self-harmed before compared with eight afterwards. And while 25 had jobs before therapy, only three were in employment afterwards.

There are many stories of families torn apart by accusations of abuse that were later retracted. "They convince people they had a much worse life than they had, which is tragic," says Patihis.

One challenge is a subtle change in terminology used in therapy. "The term 'repressed memory' has gained a bad reputation," says Shaw. Instead, she says, people now refer to buried or lost memories. Individuals are described as having the closely related concept of "dissociative amnesia", a diagnosis recognised in the latest version of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM)*, colloquially known as the psychiatrist's bible.

Meanwhile, legal cases based on recovered memory continue. In a recent search of the legal database LexisNexis, Laney Thede found more than 300 US legal cases that have used the word "repression" since 2000 and more than 2000 that reference dissociative amnesia. "This is just the tip of the iceberg, because this idea affects many cases where the word repression is never uttered, and many more that are not in the database," she says.

Where do we go from here? Some researchers feel that an important step would be to remove the term "dissociative amnesia" from the *DSM*. The American Psychiatric Association, which is responsible for the *DSM*, describes dissociative amnesia as "not being able to recall information about oneself", clarifying that it is "not normal forgetting", and "is associated with having experiences of childhood trauma, and particularly with experiences of emotional abuse and emotional neglect".

"It's really just the same idea of repressed memories, but dressed up differently," says French, who is one of many researchers who think that the diagnosis doesn't belong in the *DSM*. Laney Thede agrees. "They gave up the word but not the phenomenon," she says.

Better training and regulation for therapists could help. While psychiatrists and psychologists tend to have to undergo training to qualify, in many countries anyone can call themselves a therapist, counsellor or life coach, and offer support to people with mental health conditions.

Memory researchers like Otgaar and Loftus have also been trying to get the word out to the general public. It is here that the greatest challenge may lie. "The book stores are filled with suggestive literature," says Loftus. A quick internet search reveals plenty of symptom checklists for people who want to find out if they might have repressed memories. Sometimes even an engaging television programme can be enough of a trigger for someone to become convinced that repressed memories of trauma might explain their current low mood or poor mental health.

Otgaar believes that better education of lay-people, as well as therapists and people working in criminal justice, is the only way to put this seductive, yet scientifically unlikely, idea to bed. ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries

Jessica Hamzelou is a reporter at *New Scientist*

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# The back pages

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**Tom Gauld for *New Scientist***
A cartoonist's take on the world p55

**Feedback**
It's official: we dream more about cats than about dogs p56

**Twisteddoodles for *New Scientist***
Picturing the lighter side of life p56

## Science of gardening

# Smart ways to water

Becoming a greener gardener doesn't mean letting your plants go thirsty. It is easy to use water more wisely, says **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

## What you need

**A water butt**
**A watering can**

PETER CADE/GETTY IMAGES

LAST month, a campaign by the Royal Horticultural Society urged UK gardeners to be more environmentally friendly. One piece of advice was to get a water butt and use rainwater for watering instead of the mains.

You might think there is plenty of water to go around in a rainy country like the UK, but it is a waste of energy to give plants tap water, which has been intensively treated so it is fit to drink. Rainwater is perfectly good enough for most plants and may even be better, as tap water contains dissolved magnesium and calcium, which accumulate around the roots, raising the soil's pH and lowering the availability of other nutrients. The only exceptions are tiny seedlings, which benefit from clean tap water as they are vulnerable to infections.

If you have room to install a water butt, make sure the water doesn't accumulate organic matter, which will lead to algal growth, says Neil Phillips at the University of the West of England, Bristol, in the UK. Use a lid, and put some fine netting where the downpipe meets the lid to stop leaves getting washed in.

Phillips says we should try to avoid using hosepipes in the garden: they can use 1000 litres of water an hour, more than the average household in a day. "It's just so easy to get the hosepipe on and spray huge quantities of water about," he says.

It is better to use watering cans to direct the water to where the plants need it. And rather than watering little and often, which encourages shallow roots, give big, less frequent drinks for deep roots.

Another option is making a drip irrigation system out of an old 2-litre plastic drink bottle. Just nail a few holes in the lid, fill with water, put the lid back on and partly bury it upside down, where it can drip-feed water directly to the roots.

To reduce the garden's need for water over the longer term, stay on top of your weeding – some common weeds suck up four times as much water as crop plants do. Add an organic mulch-like manure to reduce evaporation from the surface; as the mulch gets mixed in over time, that will help the soil hold more water too.

Water-retaining silica gel granules work well, but are too expensive for widespread use. I use them for hanging baskets and pots, and also mix some into the soil under particularly vulnerable plants like tomatoes.

You can also research when plants require the most water so it isn't wasted. Tomatoes, for instance, need this when they start flowering and fruiting, but the majority of squash varieties require more water when first planted. If you are growing large, rambling squashes like courgettes and pumpkins, don't forget to put in a small cane next to the young plant, so you will be able to find the roots and water them when autumn comes and it is an overgrown monster. ▮

*Science of gardening appears every four weeks*

## Next week

Citizen science

These articles are posted each week at **newscientist.com/maker**

CHEMISTRY
LIKE COOKING, ONLY WITH EXPLOSIONS
THERE IS NO PLANET B
VACCINES CAUSE ADULTS
In the beginning was physics.
LIFE
THE UNIVERSE
42
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So when you visit the pub, the app will recognise your position and change its settings.

This can also help you track your hearing aids – just as you would a lost phone.

The find-a-hearing-aid function will give you its location when it was last connected to the phone.

The hearing aids can also act as a pair of headphones allowing you to wirelessly stream sound from your iPhone, iPad or iPod touch. They are small, tough, water resistant and fashionable too – available in a range of discreet colours,

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ASK THE AMPLIFON EXPERT
Chris Childe, Audiologist & Training Manager

**Q: Have hearing aids really changed that much in the last 20 years?**

A: Hearing aids today have so many improvements compared to what was available 20 years or more ago. Technically, the advent of digital signal processing in hearing aids transformed the ability of hearing aids to overcome all manner of hearing difficulties even in really difficult listening conditions. Physically, hearing aids are available in more fitting styles and colours with most people now being able to use very small hearing aids without any compromise in the quality of hearing improvement.

**Q: When hearing aids connect wirelessly to a smartphone or TV, is the sound quality any different?**

A: When listening to music by wireless connection to hearing aids, the sound quality doesn't suffer in any way. In fact, because sounds are received more directly into hearing aids, the quality is usually noticeably better and easily controllable using the smartphone app.

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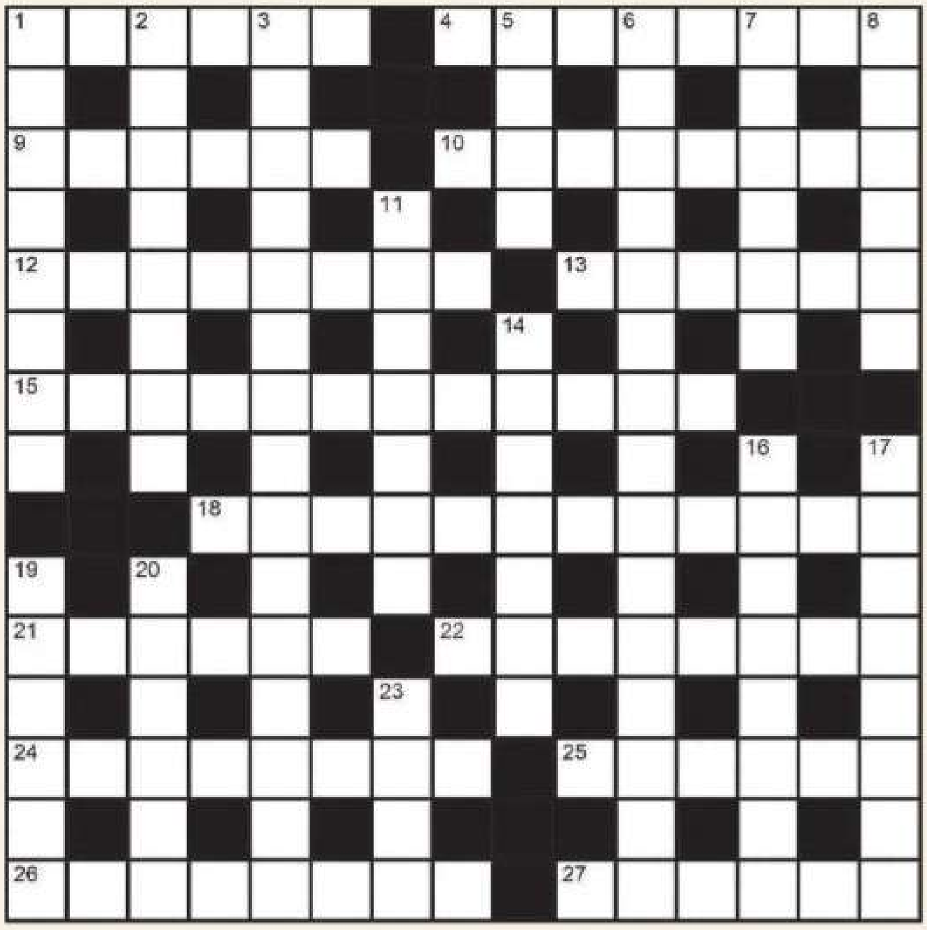
## Quick crossword #93 *Set by Richard Smyth*



**Scribble zone**

Answers and the next cryptic crossword next week

**ACROSS**

**1** Hazardous form of clinical waste (6)
**4** Solution of formaldehyde (8)
**9** Monster in the *Godzilla* franchise (6)
**10** Of skin or tissues, blue (8)
**12** Nine-sided figures (8)
**13** Scientific journal founded in 1869 (6)
**15** Poland-born author of *Solaris* and *The Cyberiad* (9,3)
**18** Male sex hormone (12)
**21** Drug formerly used as an emetic (6)
**22** ___ table, display of the chemical elements (8)
**24** Pale grey or blue-green (8)
**25** Tree with an edible seed, *Prunus amygdalus* (6)
**26** Se (8)
**27** Strain; emphasis (6)

**DOWN**

**1** Similarity; monotony (8)
**2** Feelers (8)
**3** Fast, powerful bird of prey (9,6)
**5** Banded chalcedony (4)
**6** Purple pigment, $NH_4MnP_2O_7$ (9,6)
**7** Dye mixture used in testing pH (6)
**8** Ni (6)
**11** Blow up (7)
**14** Tornado (7)
**16** Blister resulting from herpes labialis (4,4)
**17** German automobile marque (8)
**19** Fuel derived from organic matter (6)
**20** *Total* ___, 1990 adaptation of a Philip K. Dick story (6)
**23** In the NATO phonetic alphabet, Z (4)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #122

**1** Epigeal, hypogeal and viviparous are three types of which process?

**2** In what year was a magnetar observed for the first time?

**3** The Devonian, the Carboniferous and the Silurian periods all occurred in which geological era?

**4** Hydrogen cyanide was first derived from which synthetic pigment?

**5** What is the highest active volcano in the world?

*Answers on page 55*

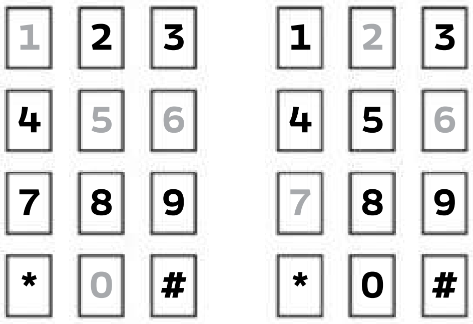
## Puzzle

*set by Katie Steckles*

### #134 No time to try

**James Blond edges along the corridors of the supervillain's base, and comes to two locked doors, each with a keypad that requires a four-digit code. He will need to get through one of the doors, but there is no time to guess a four-digit code – the number of possible combinations is staggering!**

**But wait! Some of the buttons on the keypads are visibly worn down, while others look as if they have never been pressed.**



**One door has a keypad with four worn buttons, the other has three. Blond only has time to try one door, and he will have to try all the possible combinations.**

**Which of the two keypads will give him fewer combinations to try – the one with four worn buttons, or the one with three?**

*Solution next week*

## Feeling flush

**Are perimenopausal hot flushes just a side effect of changing hormones or are there possible evolutionary advantages to them?**

***Jane Swan***
*Delabole, Cornwall, UK*
I can confirm that hot flushes contributed to my survival when packing daffodils in January and February in a cold shed at night. At times, it was difficult to tell the flush from the "daffy rash", a red burning rash you can get from the sap of cut daffodils, which we were packing for supermarkets.

The packing sheds were kept cold to stop the flowers opening, so a hot flush was a definite bonus.

***Myra Hunter***
*King's College London, author of Living Well Through the Menopause*
I think hot flushes are just a side effect of menopause. They are self-limiting for most women, and when their hormones have adjusted, the hot flushes stop. About 20 per cent of women have none or very few, 25 per cent have moderate to severe hot flushes and the rest are in between. They can be distressing and affect quality of life for some, but there are effective treatments, such as hormone replacement therapy and cognitive behavioural therapy.

> "I can confirm that hot flushes contributed to my survival when packing daffodils in winter in a cold shed at night"

Menopause itself may well be adaptive, however. Human females are unusual in that their reproductive phase of life stops well before death and before other age-related physical changes happen. Most animals and birds reproduce throughout life. Only five species are known to experience it: orcas, short-finned pilot whales, belugas, narwhals and humans. In general, non-human primates are fertile through to advanced age.

So why are humans different in this respect? Two main hypotheses have been proposed: non-adaptive and adaptive.

The main non-adaptive idea suggests that the menopause happens because there is a limited supply of eggs at birth, and humans have a considerably longer lifespan than other mammals of similar size. As a result, we run out of eggs by middle age. In other words, menopause is a by-product of a long life.

In contrast, adaptive hypotheses suggest that menopause offers benefits. Postmenopausal women don't face the dangers of childbirth, which are more common with increasing age. Other ideas emphasise the role of the mother and grandmother in supporting the next generations.

The mother idea focuses on the unusually long duration of child development in humans – and therefore the time women need to raise children. So, women need an extra 15 years or so of life after their last child is born in order to nurture their offspring.

One reason the menopause might make grandmothers more helpful to their family's survival is decreasing competition. If grandmothers and their daughters had children at the same time, their offspring would be competing for resources. The grandmother idea emphasises the evolutionary benefits of having a grandmother to assist with childcare and provide food and resources.

HILLARY KLADKE/GETTY IMAGES

Can an organism as simple as a fly display free will?

### This week's new questions

**Small choices** **Assuming free will exists, how complex does an organism have to be to exhibit it?** ***Derek Johnson****, Moreton-in-Marsh, Gloucestershire, UK*

**Raining bullets** **I cringe when I see soldiers celebrating by shooting their rifles into the air. What speed do the bullets return to earth and could they injure an unprotected head?** ***Brian Moss****, Kingsbury, Tamworth, UK*

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## The existence of time

**Aside from our perception, how can we know that time exists?**

***Ian Machell***
*Trowbridge, Wiltshire, UK*
Time – and, by inference, the mathematical construct of space-time – doesn't exist as an entity in its own right, because, unlike matter or energy, it has no physical properties.

It is just an abstract concept, derived by counting natural astronomical and subatomic cycles to build calendars and clocks for timekeeping – in other words, in order to measure and compare the start, end, duration and order of events.

***Mike Follows***
*Sutton Coldfield, West Midlands, UK*
The arrow of time or the idea that time runs in the direction of increasing entropy, or disorder, is a pretty reliable indicator that the passage of time is real and not a figment of our imaginations.

For example, imagine a car accident involving two new vehicles. Following the accident, the bodywork of both vehicles is dented and shattered glass and splintered plastic is strewn around.

If time could reverse, the wreckage would spontaneously reassemble into two pristine vehicles, yet this has never been observed.

The idea of the arrow of time is underpinned by the second law of thermodynamics, arguably the most unassailable concept in physics.

***Andy Taylor***
*Edinburgh, UK*
Aside from our perception, how can we know that anything exists?

***Nick Godwin***
*Edinburgh, UK*
This question can be answered

## Tom Gauld
*for New Scientist*

WELL, EITHER OUR GROWTH SERUM HAS BEEN WILDLY SUCCESSFUL OR THE HALLUCINOGEN TANK IS LEAKING AGAIN.

in two ways, one of which is long, the other short.

Time is rather like money, in that it doesn't exist as an independent entity, but only as an instrument for measuring certain qualities of things. In the case of time, the particular quality is change.

In its simplest form, the type of change that time measures is that of spatial position of objects relative to each other. This is the fundamental basis of its existence, as observed long ago in the daily changing position of the sun in the sky.

Of course, our perception of time has changed during the development of different civilisations and we now think of it more as movement of pointers around a clock face or seconds ticking by on an electric watch.

But however we think of it, it is always in relation to change, at some level, in the spatial relationship between objects.

That was the long answer. Here is the short one: we can't know that time exists. Time exists only as a cognitive instrument for measuring change.

> **"Time does not exist as an entity in its own right, because it has no physical properties. It is just an abstract concept"**

## White splat

**Considering all the things birds eat, why are their droppings mostly white? (continued)**

***Raman Joshi***
*Brampton, Ontario, Canada*
Much of the previous correspondence on this topic (7 August) outlined that bird droppings are mainly white because of uric acid.

When I was driving a few weeks ago, a bird released its waste on my windshield. Having a medical interest in the condition of gout, which is caused by uric acid, I scraped off some of the white material and looked at it under my polarising microscope.

I saw animal and plant matter, but no gout crystals. So I tried using another polarising microscope with better magnification and lenses than mine. When I looked at the lab's "standard" slide of uric acid crystals, I saw a field light up with long uric acid crystals. When I looked at my slide, there were no such crystals, even at maximum magnification.

On reviewing the topic further, I came across a 2019 article in the *Journal of Ornithology* with the title "A re-evaluation of the chemical composition of avian urinary excreta". In this study, none of the specimens examined by the authors contained uric acid, but instead ammonium urate, struvite and two previously unidentified compounds.

Although birds excrete uric acid, it is changed into other compounds by their cloacal microbiota before excretion, and no uric acid was noted in the bird droppings. ▮

## Answers

### Quick quiz #122
*Answers*

**1** Germination
**2** 1979
**3** The Palaeozoic era
**4** Prussian blue
**5** Ojos del Salado, on the Argentina-Chile border. It is 6893 metres high

### Cryptic crossword #67 *Answers*

**ACROSS 7** Alpha Centauri, **8** Payloads, **9** Test, **10** Carrion, **12** Trait, **14** Stabs, **16** Bentham, **19** Emit, **20** Asteroid, **22** Standard model

**DOWN 1** Flea, **2** Choler, **3** Octagon, **4** Anise, **5** Matter, **6** Brassica, **11** Automata, **13** Peptide, **15** Batons, **17** Torpor, **18** Radar, **21** Ibex

### #133 Think tank
*Solution*

The brick dimensions are 12 by 6 by 4 centimetres. If we call the brick length L, then we can take the base area of the tank $(3L/2) \times (2L/3)$ and subtract the area of the brick resting on the bottom of the tank $L \times (L/2)$.

We then multiply the result by the new water height $L/3$, which is the height of the brick. The expression obtained should equal the volume of water (including the fish) in the tank, $(3L/2)(2L/3) \times 2$, calculated without the brick. This gives the equation $L3/6 = 2L2$.

The only solutions are $L = 0$ (invalid) and $L = 12$ cm. The calculations $L/2$ and $L/3$ give the width and height of the brick, respectively.

## IT'S BEHIND THE MILK!

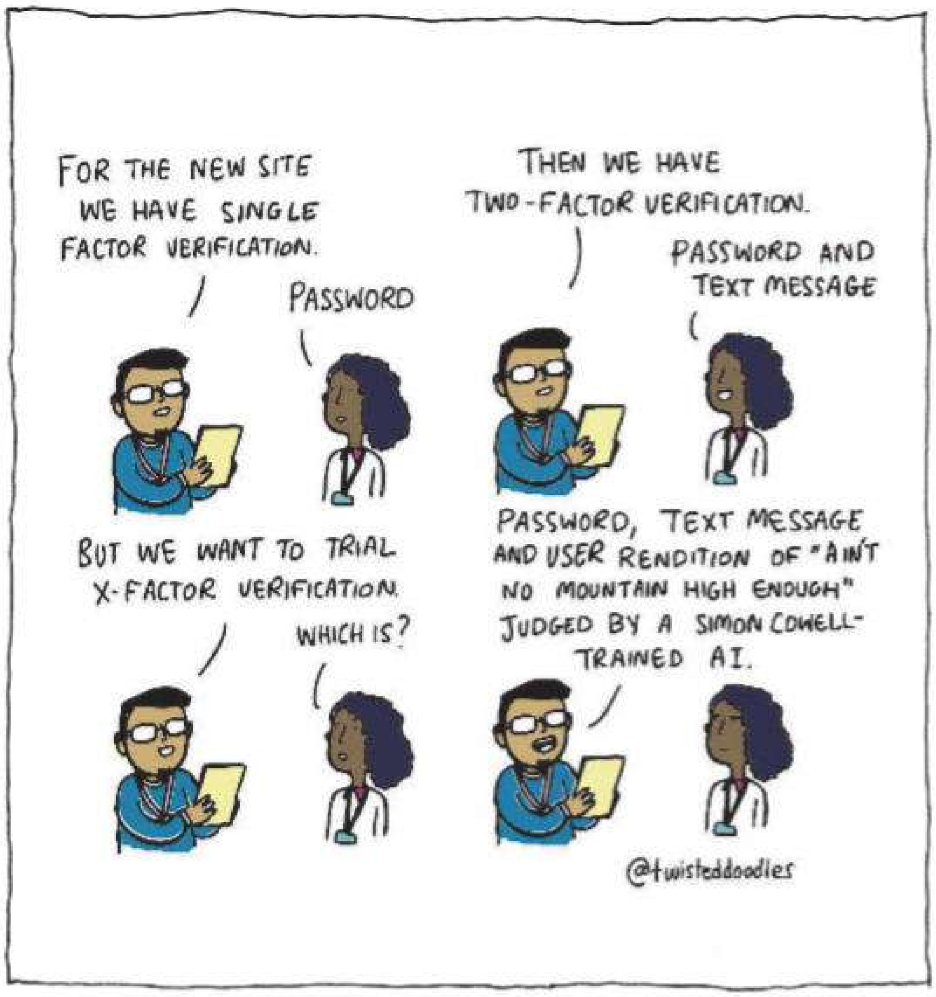
**Feedback is *always* favourably inclined towards anyone who says by way of introduction that they are "a long time subscriber who *always* reads NS from back to front". So we are smiling beneficently at Cathrine Lowther as she draws our attention to an unfamiliar paper from the medical literature.**

**"Admittedly, it is 16 years old," she says. Dear Cathrine, our extensive piling system has a murky dust-ridden layer towards its bottom that some archaeologists associate with the sacking of London by Boudicca. The paper in question, by Andrew Macnab and Mary Bennett, is entitled "Refrigerator Blindness: Selective loss of visual acuity in association with a common foraging behaviour".**

**The researchers write that three male offspring, aged 9 to 14, of Bennett were observed to sporadically experience a profound visual problem – this condition being exclusively associated with an inability to find stuff in the fridge. "Even with calm and constructive maternal encouragement and direction," they write, "the desired object typically would remain unseen until the mother-physician attended the fridge-side and physically identified the precise location of the item. This behaviour was noted only sporadically among the female members of the household, but was unremitting among the males."**

**Despite an extensive online search, Cathrine was unable to come up with any follow-up research. "I can't help but wonder if that is because male scientists fail to appreciate how important and widespread this problem is, or perhaps because they are too busy rooting through the lab fridge searching for their lunch bag that, they swear, they put in there only two hours ago," she writes. We couldn't possibly comment – but we would welcome any further reader insights into this or related phenomena.**

## Twisteddoodles *for New Scientist*


FOR THE NEW SITE WE HAVE SINGLE FACTOR VERIFICATION.
PASSWORD
THEN WE HAVE TWO-FACTOR VERIFICATION.
PASSWORD AND TEXT MESSAGE
BUT WE WANT TO TRIAL X-FACTOR VERIFICATION.
WHICH IS?
PASSWORD, TEXT MESSAGE AND USER RENDITION OF "AIN'T NO MOUNTAIN HIGH ENOUGH" JUDGED BY A SIMON COWELL-TRAINED AI.
@twisteddoodles

### Got a story for Feedback?

**Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT**
**Consideration of items sent in the post will be delayed**

## Eye for an eye

He doesn't say whether it was prompted by rootling in his fridge, but Jeroen Gildemacher in Groningen, the Netherlands, was recently booking an appointment with his optometrist online. He wonders aloud whether the pitfalls he encountered – bad contrast, text extending rightwards beyond the edge of the internet and so on – were in this case bad design, or instead clever marketing.

Mainly, though, he experienced a counterexample to the sometimes overbearing accuracy of GPS coordinates (21 August). At the end of the process, under the heading "You can find us here", he found a map 330 pixels wide – of the entire world.

It's simple, Jeroen. This is an example of the old "if you drown, you weren't a witch" school of thought – if you can find your way to the optometrist, you don't need to go to the optometrist.

## Cats on the brain

**"Speaking of studies that didn't need to be done," says a colleague – we weren't, but we shall, gladly – as they forward on "Dreaming about cats: An online survey", a new paper in the American Psychological Association journal *Dreaming*.**

**The topline results are that cat owners dream more about cats, that cats show up in about 5 per cent of remembered dreams and that therefore, on this metric, they are better than dogs. A small percentage of participants indicated that they'd had negative experiences with cats in the past; "this is related to the frequency of dreams with threatening cats", the researchers write. So now you know.**

## Rod for your own back

Further to the UK's back-to-the future re-embrace of imperial measurements (25 September), David Clark recalls that when the original switch to the metric metre/kilogram/second was mooted in the 1970s, someone at his engineering college in the West Midlands suggested we should move instead to the rod-ton-fortnight system. They went as far as publishing a series of conversion tables, he says, showing, for example, that 30 miles an hour under the old system equated to about 3.26 million rpf (rods per fortnight) in the new.

We note in passing that this is also the number of light years in a megaparsec, although we will leave it as an exercise for the reader to work out whether that's a coincidence. "The preparation of the tables took an impressive amount of effort as computer time was pretty well unobtainable and electronic calculators were unavailable," says David. We are unsure whether we should see this as a virtue. We are also slightly worried that whoever it was might have got their mitts on the levers of power in the meantime.

## Whistle-blowers wanted

**An as-yet nameless phenomenon is in evidence in a paper from 2017 in the journal *Nature Communications* that Simon Goodman points out to us. Alongside lead author A. Sucker, further authors include a B. Real and a lively trio of Natalia Pieper, Mirko Trilling and Susanne Horn. We'd love to know what's going on there.**

## Dare not speak its name

More familiarly, you reveal to us that the CEO of Transparency International Australia is Serena Lillywhite, that Nick Fisch has been given a grant to attend the World Fisheries Congress and that the CEO of Epik, a company that provides internet services to some ugly far-right groups, is Robert Monster. But let's not go there. ▮

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The VAX Platinum SmartWash is the UK's first carpet washer with Motion Sense technology; there's no trigger, it automatically washes and dispenses clean water and solution when you push forward and dries when you pull back - meaning it's effortlessly simple to use, and with the dry-only mode, it helps dry your carpets in as little as an hour.

**Motion Sense Technology**

The UK's first Carpet Washer with motion sense technology - automatically dispensing solution and washing when moving forward and drying when pulling back.

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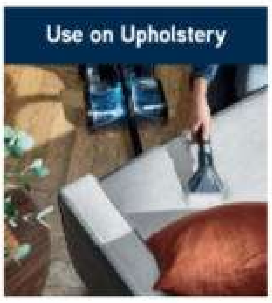

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†When using dry only mode. Δ Cleaning effectiveness on carpet, tested according to IEC 62885-3:2014 part 5.2.1. For further information email claimsinfo@VAX.co.uk. *When used with Vax Platinum Antimicrobial solution, use biocides safely, always read the label & product information before use. Orders before 5pm Monday-Friday will be next day delivery. Outside of these times, orders will be despatched next working day. Offer only while stocks last.

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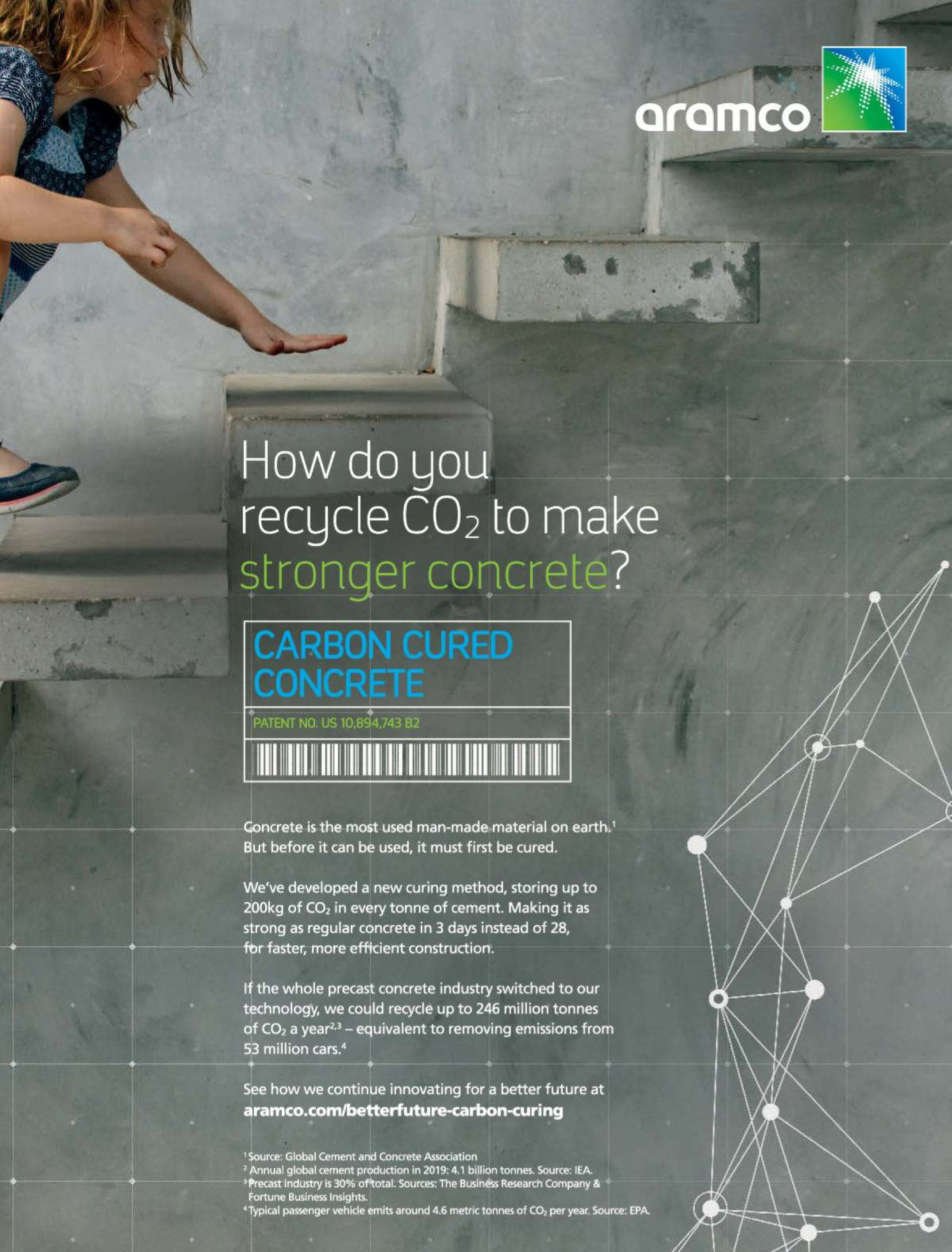

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[1] Source: Global Cement and Concrete Association

[2] Annual global cement production in 2019: 4.1 billion tonnes. Source: IEA.

[3] Precast industry is 30% of total. Sources: The Business Research Company & Fortune Business Insights.

[4] Typical passenger vehicle emits around 4.6 metric tonnes of $CO_2$ per year. Source: EPA.